E/CONF.39/A/315
1 Nov.1962
ORIGINAL : ESPANOL

CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

Punto del programa : A.3.2.2

Argentina

PRONOSTICOS DE ESCURRIMIENTO EN RIOS ARGENTINOS DE REGIMEN NIVAL

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Las monografías presentadas en la Conferencia de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología en Beneficio de las Regiones Menos Desarrolladas constituyen documentos de trabajo de dicha Conferencia. Se publican tal como han sido presentadadas por los colaboradores y los puntos de vista expresados en ellas corresponden a los colaboradores. (Veánse notas al dorso.)

NOTAS

1. Las monografías seleccionadas para las Sesiones Generales serán distribuidas en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

2. Las monografías seleccionadas para las Sesiones Especiales serán distribuidas en la Conferencia únicamente en uno de los idiomas oficiales antes indicados.

3. Los resúmenes de las monografías presentadas por los colaboradores serán distribuidos en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

4. No se procederá a la distribución general de las monografías y resúmenes con antelación a la Conferencia. Unicamente serán publicadas en cantidades limitadas con antelación a la Conferencia para uso exclusivo de las delegaciones de los gobiernos participantes y de otros participantes autorizados. La publicación con posterioridad a la Conferencia y la distribución general de las actas y debates de la Conferencia seguirán las prácticas de las Naciones Unidas establecidas por la Junta de Publicaciones de las Naciones Unidas.

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1. Generalidades

a) La región del territorio argentino que se extiende al pie de la Cordillera de los Andes es un ambiente físico netamente árido, con precipitaciones del orden de los 200 mm y aún menores. La escasez de las precipitaciones ha hecho necesario el desarrollo de aprovechamientos hidráulicos con fines de regadío los cuales permiten en la actualidad el cultivo de más de 600.000 hectáreas, cuya producción valorable en unos u$s 190.000.000 anuales, constituye el principal recurso económico de la región.

b) Los sistemas de regadío aprovechan distintos cursos de agua que descienden de la Cordillera, donde se producen precipitaciones de mucho mayor magnitud que en el área pedemontana y bajo la forma preponderante de nieve. El predominio de la nieve se debe a la gran altitud de las cuencas imbríferas y al régimen invernal de las precipitaciones.

c) La utilización de los ríos andinos no se limita al riego solamente pues también constituyen un importante recurso hidroeléctrico. En la actualidad la potencia instalada sobre estos sistemas fluviales es de 135.000 kw; en construcción se hallan 270.000 kw y existen proyectos concretos de aprovechamiento de más de 2 gW.

d) El valor e influencia socioeconómica de los recursos hídricos superficiales de la región andina explica los esfuerzos volcados a estudios e investigaciones de distinta índole que conduzcan al mejor conocimiento y más integral explotación de los mismos. Uno de los estudios tendientes a cumplir tales propósitos es el que se refiere a la predicción a largo plazo de los aportes fluviales.

e) Esta monografía tiene la finalidad de informar brevemente sobre distintos aspectos de la elaboración de pronósticos de escurrimiento en la República Argentina, tales como sus fundamentos, antecedentes, organización, cuencas en estudio, utilidad, técnicas operativas, resultados, etc.

2. Fundamentos

a) Los pronósticos de escurrimiento se basan en que estando los ríos primordialmente alimentados por nieve y existiendo un desfasa

je entre causa y efecto, vale decir entre la ocurrencia de la precipitación y el incremento de los caudales que a ella responden, una evaluación de la cubierta nevada hará posible conocer los aportes del río con cierta seguridad y con suficiente anticipación.

b) La evaluación de la cubierta neveda puede obtenerse a través de mediciones directas de nieve, durante el período de acumulación de la misma y que luego son correlacionadas con los respectivos escurrimientos fluviales que se originan de la fusión nival.

3. Antecedentes

a) Los estudios de nieve con miras a la emisión de pronósticos dieron comienzo en la República Argentina hace unos 25 años pero durante los primeros 10 años tuvieron caracter preliminar y no sistemático, restringiéndose a reconocimientos limitados de áreas nevadas, instalación de nivómetros, construcción de refugios y sendas de acceso, etc. En 1948 visita el país el Dr. James E. Church, verdadero precursor de estas técnicas de predicción y en compañía del Ing. Dagoberto A. Sardina, a quien debe señalarsele igual mérito en el orden nacional, realizan un prolongado reconocimiento de todas las cuencas cordilleranas. Este reconocimiento permitió la elaboración de un completo informe que sirvió para sentar las bases de organización de un servicio de pronóstico, como dependencia de la empresa estatal Agua y Energía Eléctrica y bajo la jefatura del Ing. Sardina.

b) En 1949 se inician las mediciones directas de nieve según el método sugerido por el Dr. Church, comenzándose por la cuenca del Río San Juan e incrementándose progresivamente a otras cuencas con el fin de ampliar el área sujeta a predicciones.

c) En 1953 fallece el Ing. Sardina al ser sepultado por un alud de nieve mientras encabezaba una comisión invernal de mediciones nivométricas en el Valle de los Patos.

d) La emisión oficial de pronósticos se inicia en 1953 con la cuenca del Río San Juan y se amplía en 1954 a los ríos Mendoza y Atuel, en 1956 al Río Colorado, en 1958 a los ríos Tunuyán y Diamante, en 1959 al río Limay y en 1961 al Río Neuquén.

4. Cuencas fluviales en estudio

a) En la actualidad el área para la cual se emiten pronósticos cubre la totalidad de las cuencas que drenan la vertiente oriental de la Cordillera de los Andes entre los paralelos 29º y 41º de latitud Sur y que son de N a S las correspondientes a los ríos San Juan, Mendoza, Tunuyán, Diamante, Atuel, Colorado, Neuquén y Limay. Con excepción de los dos últimos cursos de agua, los demás son de régimen exclusivamente nival, con máximos de primavera-verano y mínimos de otoño-invierno.

b) Los ríos Neuquén y Limay tienen una alimentación mixta pluvionival y ello se debe a que pese a la mayor latitud de estas cuencas, el brusco descenso de la altitud de la Cordillera de los Andes que se observa al Sur del paralelo 37º, determina la existencia de lluvias que no se observan en las cuencas más septentrionales. Estos dos ríos tienen dos ondas de crecida, una de invierno debida a lluvias y otra de primavera-verano producida por fusión de la nieve acumulada en invierno.

5. Organización

a) La empresa estatal Agua y Energía Eléctrica, organismo que proyecta, construye y explota servicios de regadío e hidroelectricidad, tiene a su cargo la elaboración de los pronósticos a traves de su Sector Recursos Hídricos.

b) A su vez el Sector Recursos Hídricos tiene una División Nivología que realiza las tareas de campo y gabinete necesarias para la elaboración de las predicciones. El personal permanente afectado a estos trabajos se compone de tres profesionales y un técnico.

c) Las mediciones de nieve se realizan con el empleo de un helicóptero para la mayor parte de las cuencas y tienen lugar en forma periódica durante el invierno. Los valores empleados para la elaboración de los pronósticos corresponden normalmente a la medición que se efectúa a fines de agosto o principios de setiembre, fecha a partir de la cual comienza ya el proceso de fusión de la nieve en las altas cuencas andinas.

d) Los pronósticos para todas las cuenas en estudio se elaboran a mediados de setiembre y son inmediatamente comunicados a todos los organismos interesados en los mismos, los que a su vez realizan la difusión local, asegurando el conocimiento público general. Las previsiones de aportes fluviales se realizan para los lugares de mayor interés en cada cuenca y tales como cabeceras de sistemas de regadío, centrales hidroeléctricas, embalses, etc.

6. Costos

El costo anual de los pronósticos, incluyendo los gastos de personal, equipo, helicóptero, instrumental, etc. alcanza a la suma de u$s 20.000.-

7. Valores pronosticados

a) Los valores o magnitudes que se pronostican en forma sistemática para todas las cuencas y para cada lugar en particular son los siguientes:

i) Volumen del período octubre-marzo
ii) Caudal máximo diario del período
iii) Probable distribución mensual del volumen estacional
iv) Relación porcentual del volumen pronosticado con respecto al año anterior y al valor normal.

b) A partir del presente año y para las cuencas de los ríos Mendoza, Tunuyán, Diamante, Atuel y Colorado se pronosticará también el volumen del período octubre-setiembre; vale decir se elaborará una previsión semestral y otra anual. En el caso del río Limay, además de los valores detallados en a), se realizan también pronósticos de mínimos.

8. Utilidad y aplicaciones

a) El conocimiento anticipado de la ocurrencia de un fenómeno con un margen de seguridad aceptable constituye siempre una circunstancia ventajosa pues permite, cualquiera sea la índole del fe

nómeno y través de medidas o decisiones adecuadas, aprovecharlo plenamente si el evento es beneficioso o reducir sus efectos si es perjudicial. En el caso de los escurrimientos fluviales caben perfectamente tales consideraciones.

b) Concretamente pueden señalarse los siguientes beneficios importantes obtenibles con los pronósticos.

i) Regulación de las superficies de cultivo: existen miles de hectáreas de riego eventual y cuyo cultivo está condicionado a las mayores disponibilidades de agua. Los pronósticos aseguran su utilización en años de abundancia y evitan esfuerzos y gastos inútiles en años de pobreza de agua.

ii) Prevención de crecidas: en años excesivos se dispone del tiempo necesario para adoptar medidas de seguridad y prevención que limiten los daños y perjuicios.

iii) Explotación de centrales hidroeléctricas: los pronosticos aseguran una más eficiente programación de la explotación y de la demanda.

iv) Aprovechamientos de propósito múltiple: en los embalses que cumplen varias finalidades resulta difícil conciliar los intereses de los distintos usuarios. Por ejemplo los viculados a la generación hidroeléctrica les interesa mantener los más altos niveles en el embalse, por el contrario, los que temen el efecto de las crecidas insisten en bajar los mismos para asegurar la máxima capacidad de retención. También son frecuentes las controversias derivadas de la distinta distribución de las demandas para riego y energía. Los pronósticos permiten la mejor explotación del sistema y el menor enfrentamiento de intereses opuestos.

v) Créditos bancarios: la incidencia de las disponibilidades hídricas en el monto y valor de la producción agrícola e industrial, hace que el conocimiento previo de aquéllas permita una regulación adecuada de créditos bancarios y otras financiaciones.

vi) Muchos otros beneficios deben agregarse a los anteriores, tal vez menos evidentes, pero igualmente significativos y que se vinculan con explotaciones mineras, transportes ferroviarios y carreteros, turismo, actividades comerciales, etc.

9. Operaciones de campo

a) Las mediciones de nieve se realizan en lugares apropiados denominados "secciones nivométricas". En dichos lugares se repiten todos los años cateos en puntos fijos que tienen por objeto determinar el contenido medio de agua de la nieve. El instrumental empleado, similar al utilizado en los Estados Unidos, es del tipo Mount Rose.

b) Hasta 1960 el acceso a las secciones nivométricas se realiza-

ba a lomo de mula y en la mayor parte del trayecto a pie o con esquíes. Aún cuando se disponía de una adecuada red de refugios, las grandes distancias a recorrer, la hostilidad del medio, la posibilidad de aislamiento por temporales o avalanchas de nieve y los peligros de enfermedades o accidentes con remotas posibilidades de rápido auxilio, exigían del personal afectado a la realización de las mediciones, esfuerzos y vocación considerables. Sin duda la faz de las operaciones de campo era la etapa más dificultosa de los estudios nivológicos.

c) A partir de 1961 y luego del ensayo de medios mecánicos terrestres de acceso que mostraron una utilidad limitada por las condiciones topográficas adversas, fué empleado un helicóptero para llegar a los sitios de medición. Este nuevo medio de acceso mejoró notablemente las condiciones operativas y permitió la ampliación de la red de secciones nivométricas, reducción de costos de operación, seguridad de acceso aún en años extremadamente ricos de nieve, eliminación de penurias, disminución de riesgos y limitación del personal necesario para realizar las mediciones.

d) En la actualidad los pronósticos se basan en las mediciones obtenidas en una red de 25 secciones nivométricas y se complementan con observaciones que se realizan en la vertiente chilena. Si bien es reducido el número de sitios de medición frente a la enorme amplitud del área en estudio, las secciones nivométericas observadas han mostrado ser suficientemente representativas de las precipitaciones que tienen lugar en la Cordillera.

10. Correlaciones nivofluviales

a) La correlación entre las reservas de nieve de cada cuenca o un índice de ellas, obtenido a través de las mediciones en las secciones nivométricas y los correspondientes aportes fluviales, fué realizada empleando distintas técnicas o procedimientos que se adecuaban a la información disponible y a la constante evolución de los conocimientos específicos, resultante de un estudio más profundo de los problemas y a lo que la misma experiencia acumulada aconsejaba.

b) En un principio y ante la falta de suficiente información los pronósticos se calcularon en base a una simple relación directa entre caudales y mediciones de nieve del año pronosticado e iguales variables del año o años anteriores. Cuando se pudo contar con una serie de valores sucesivos de caudales y mediciones de nieve, se calcularon ecuaciones de correlación entre ambas variables.

c) Las correlaciones nivofluviales empleadas vinculan en cada cuenca el contenido de agua de la nieve correspondiente a la medición realizada en el momento de máxima acumulación en una o más secciones nivométricas con los posteriores derrames fluviales para el período octubre-marzo y octubre-setiembre. En algunos casos especiales se introducen algunas otras variables en la correlación y tales como el caudal del invierno previo a la estación de pronóstico. También se ha conseguido mejorar algunas correlaciones introduciendo índices de la evaporación de la nieve.

d) Para los pronósticos del escurrimiento del Río Limay se emplea una técnica distinta que no se basa en mediciones directas de nieve como en el resto de las cuencas. Las previsiones se realizan por empleo de una correlación múltiple cuya variables independientes

son los caudales de invierno previo, las temperaturas invernales y el almacenamiento lacustre y subterráneo. Este método especial se justifica por la complejidad del funcionamiento hidrológico de la cuenca del Limay, cuyos caracteres especiales la distinguen de los otros ríos.

e) Las predicciones de los caudales máximos se efectúan en base a correlaciones calculadas entre volumen y pico de la onda de crecida. Estas correlaciones son bastantes ajustadas si bien pueden esperarse errores de mayor significación que los que resultan de los pronósticos de volumen.

f) El pronóstico de la distribución mensual del volumen estacional es bastante inseguro a la fecha de emisión de las predicciones pues tal distribución está asociada a condiciones meteorológicas imprevisibles en tal oportunidad. Sin embargo es posible reajustar los pronósticos durante la misma estación de pronósticos y al ir conociendo la marcha de las temperaturas, insolación, etc.

11. Resultados

a) Los resultados obtenidos hasta el presente en los pronósticos de escurrimiento deben estimarse como muy satisfactorios, pudiendo esperarse que mejoren aún en el futuro, a la luz del mayor y mejor conocimiento de los factores condicionantes del relacionamiento nivofluvial y de las posibles causas de distorsión. Prueba de ello es que las correlaciones últimamente calculadas han permitido mejorar notoriamente la seguridad de las predicciones.

b) Desde 1953 a la fecha se han emitido oficialmente 40 pronósticos de volúmenes estacionales para las distintas cuencas en estudio con la siguiente distribución de errores porcentuales entre lo real y lo previsto:

de 0% a 10% de error:	15 pronósticos	= 38%	del total
" 10% " 20% " " :	17 "	= 42%	" "
más del 20% " " :	8 "	= 20%	" "

c) Si se toman en cuenta las correlaciones actuales vale decir las que serán empleadas para la estación de pronóstico primavera-verano 1962/63, los desvíos porcentuales acusan la siguiente distribución sobre un total de 73 valores:

de 0% a 10% de error:	55 valores	= 75 %	del total
" 10% " 20% " " :	17 "	= 24 %	" "
más de 20% " " :	1 "	= 1 %	" "

d) También han mostrado ser muy precisas las correlaciones nivo fluviales anuales (7.b).) pues sobre un total de 42 valores se observa:

de 0% a 10% de error:	37 valores	= 88%	del total
" 10% " 20% " " :	5 "	= 12%	" "

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1. Se han descubierto manifestaciones y yacimientos con minerales radiactivos en la República Mexicana dentro de muy variados ambientes geológicos. Las rocas huéspedes que los contienen van en edad desde el Precámbrico hasta el Cuaternario. En términos generales la mineralización de uranio se encuentra confinada a gneisses y esquistos en la Península de Oaxaca y en la Cuenca de Sonora; a sedimentos marinos calcáreo-arcillosos, de edad cretácica, en el Geosinclinal Mexicano, los cuales se hallan relacionados estructuralmente con la Península de Coahuila y con el Geo-Anticlinal Occidental; a sedimentos clásticos de carácter continental y de edad Pre-Terciaria, en la vertiente oriental de la Sierra Madre Occidental; a sedimentos clásticos continentales, triásico-jurásicos, en la Cuenca de Sonora, y a rocas ígneas intrusivas y metasedimentarias, así como a dacitas terciarias, en la región Nor-Central del Estado de Sonora. Igualmente se encuentran manifestaciones al parecer importantes de yacimientos de uranio en la Vertiente Oriental de la Sierra Madre Occidental, dentro del Estado de Durango, en rocas volcánicas.

a) Por falta de espacio, no es posible detallar el total de localidades con manifestaciones radiactivas que en algunos casos han dado lugar a ubicar zonas de tonelajes reducidos. Pero puede afirmarse que en mineral extraído, positivo, probable y posible, se cuenta actualmente en la República con la cifra cercana a las ochocientas mil toneladas con ley superior a 0.10% U_3O_8 en los Estados de Durango, Chihuahua y Sonora, principalmente. Existen localidades que por haberse estudiado de un modo preliminar en Coahuila, Querétaro, Zacatecas, Sinaloa, Estado de México y Oaxaca, no ha sido posible conocer por ahora si contienen contingentes económicos recuperables.

2. La evaluación de yacimientos con minerales radiactivos no difiere fundamentalmente, en su técnica, de la que se practica para yacimientos de otra composición mineralógica. En efecto, el criterio a seguir tiene por objeto conocer el tonelaje dentro de sus categorías de positivo, probable y posible y el correspondiente U_3O_8 químico. Las formas y dimensiones distintas que adoptan los yacimientos uraníferos en el subsuelo, así como las variaciones en las leyes del mineral radiactivo de un lugar a otro del yacimiento, hacen imprescindible estimar las reservas de un modo sistemático, siguiendo un método a fin de que la información proporcionada sea correcta. Cuanto mayor sea el acervo de datos con que se cuente, considerando que se puede depender de ellos con cierto grado de confianza, mejores serán los resultados de una cuantificación de reservas de mineral.

a) En el caso de yacimientos con minerales radiactivos puede ciertamente realizarse un conocimiento bastante aproximado del volumen de reservas, entre otros métodos, mediante una red de barrenaciones con diamante y con datos de radiometría, asumiendo que existe un equilibrio sensible entre el contenido radiométrico y el químico en el yacimiento de que se trata. De no haber esta última relación, se determina el contenido químico de U_3O_8 de las muestras representativas. Mediante los datos proporcionados por barrenaciones con broca de diamante, o bien mediante la realización de obras de mina, o aún, cosa común, con los dos métodos, puede delinearse la geometría o forma de los cuerpos mineralizados en el subsuelo. De esta manera se estiman los tonelajes o reservas. Se está hablando de un cuerpo descubierto, sea mediante prospección terrestre o bien mediante otros métodos directos o indirectos, y el problema será conocer sus características económicas.

3. Mineral positivo es el que se ha bloqueado por cuatro lados; es prácticamente - mineral a la vista. Mineral probable o indicado es aquel para el cual tanto el tonelaje como la ley son estimados parcialmente a partir de medidas específicas, muestras, o datos de producción, y parcialmente a partir de la proyección dentro de distancias razonables de acuerdo con la evidencia geológica. Mineral posible o inferido es aquel para el cual las estimaciones cuantitativas se basan principalmente en el conocimiento más o menos amplio del carácter geológico de los depósitos. Las estimaciones pueden basarse en la evidencia que pueda incluir la comparación con depósitos de tipo similar. Los cuerpos que están ocultos pueden incluirse en caso de - haya evidencia geológica específica en relación a su presencia.

4. El abastecimiento de materia prima uranífera en un país como México, con demostraciones geológicas favorables, es función de las condiciones de exploración continuada y planeación a largo alcance. Un país de los recursos técnicos, económicos y humanos como Estados Unidos necesitó entre 5 y 8 años de trabajo intensivo antes de que se tuviera un suministro adecuado de mineral de uranio. Por lo tanto, entre los principales objetivos para los programas de apreciación, debe incluirse la delineación de áreas favorables y la estimación de las potencialidades de los recursos uraníferos, así como la evaluación de los factores económicos que afectan la explotación. Cada uno de estos objetivos requiere mucho estudio e investigación. El mapeo geológico y las técnicas de exploración radiométricas adecuadas han dado cuenta de que existen criterios definidos para ubicar zonas uraníferas entre las regionales y las locales propiamente hablando, máxime si el medio ambiente es el de sedimentos.

a) Además de delinear áreas favorables, un programa de apreciación de recursos intentaría tratar el problema de la estimación de áreas potenciales de uranio. Los - criterios geológicos pueden distinguir terreno no apropiado empíricamente, pero las estimaciones cuantitativas de uranio potencial en zonas favorables constituyen problemas complicados. Es más fácil eliminar áreas individuales como no favorables, - que garantizar la existencia de depósitos en una área favorable.

b) Todas las investigaciones deben realizarse dentro de un cuadro económico que - sirve para indicar qué material es obtenible a cierto precio.

c) Como primera parte del programa en general de estudio y evaluación de áreas con posibilidades de obtener yacimientos con minerales radiactivos, se considera el tópico fotogeológico seguido de reconocimiento aéreo, a fin de realizar una evaluación geológica preliminar antes de empreder las tareas especializadas de campo. Influye en la evaluación de los yacimientos, además de su tonelaje y su ley, la profundidad a la cual eventualmente se extraería el mineral radiactivo. Una vez salvadas las - pruebas fundamentales de prospección en México, a partir de manifestaciones superficiales se han realizado las obras de mina hacia la profundidad.

d) Uno de los métodos que se realizan para investigar la potencialidad y la ley — del mineral radiactivo, es el que presupone el trazado de triángulos que resultan - de unir los puntos indicados por los barrenos, considerando una profundidad promedio para cada conjunto de 3 perforaciones. Una variación de ese método es la que - se conoce momo de aristas de influencia, la cual usa prismas poligonales formados - alrededor de cada barreno por bi-sectores perpendiculares de las líneas que conectan los barrenos. La barrena de diamante únicamente toca e intercepta el yacimiento. En consecuencia, la estimación de volumen de un cuerpo mineral a menos que se - corte en un gran número de puntos, tiene que ser considerado cuidadosamente para —

clasificar dentro de las categorías del positivo, probable o posible, tratando - siempre de verificar por medio de trabajos de desarrollo. La combinación de varios métodos es siempre la clave para decir la última palabra en relación a situaciones- de duda.

e) No debe desconocerse el hecho de que en la explotación subterránea de yacimientos, puede recuperarse del 80 al 90% del mineral estimado, en condiciones óptimas.- Una cifra muy conservadora la constituye el 65% en lo que se refiere a recuperación real.

f) La forma qué afectan los cuerpos mineralizados de uranio, influye en su evaluación, ya que una tendencia geométrica de carácter irregular como ocurre en la Sierra de "La Cal", Municipio de Nazas, Dgo., da origen a tener que realizar numerosas obras de mina y barrenaciones con broca de diamante para delimitar los bloques o zonas mineralizadas, en tanto que la forma lenticular o de manto como en Garame, Santiago Papasquiaro, Dgo. (y de baja ley) la explotación podrá ser un tanto más sencilla y por ende, más económica.

g) En la evaluación del yacimiento se tiene en cuenta los usos destinados para el - mineral en exploración. Es imprescindible para estimular la expansión rápida de la- energía atómica, suministrar a bajo costo el mineral de uranio de alta ley, durante- un tiempo grande, el mayor que sea posible.

5. Los yacimientos que a la fecha han dado cuenta del mayor contingente de minerales radiactivos se describen brevemente a continuación. Véase fig. I.

a) Los Amoles.- El área donde se ubica la Mina de "Los Amoles" se encuentra 16 - kilómetros al noreste de la población de Rayón, Municipio del mismo nombre, Estado- de Sonora. Situada dentro de la cuenca paleozoica de Sonora, la mineralización está asociada a rocas ígneas intrusivas y metamórficas, siendo el control de la misma por fracturas. Se ha encontrado mineral primario en forma de pechblenda hollinosa- y otros posiblemente de carácter secundario aún no identificados. Con estudios geológico-radiométricos que se realizaron como parte de un programa amplio dentro del- Municipio de Rayón, se consideró necesario conocer la potencialidad del yacimiento - con obras de mina. A la fecha se han realizado más de 750 metros lineales en laboríos mineros, como puede parcialmente apreciarse en el plano de la Fig. II; habiéndose delimitado una zona preliminar radiactiva con mineral indicado e inferido, seda cuenta de cerca de 50,000 toneladas con ley media de 0.5% U_3O_8. Para obtener - esta figura se han muestreado las obras mineras en las partes mineralizadas, a intervalos de 2 a 4 metros, cada una, representando ensayes radiométricos y químicos - promedio del cielo y las paredes de la obra en cuestión.

b) Mina "La Luz del Cobre.- Situada a 2 kilómetros al poniente de San Antonio de - las Huertas, Municipio de Soyopa, Estado de Sonora, esta localidad se encuentra ubicada en formaciones triásico-jurásicas, en las estribaciones occidentales de la Sie-

rra Madre Occidental. La mineralización de torbernita y otros minerales de cobre, indistintamente asociados, se localiza en fracturas y en los contactos de una chimenea con la roca encajonante. A la fecha se han realizado laboríos mineros de gran extensión que aproximadamente dan cuenta de más de 4,000 metros lineales, habiéndose bloqueado un contingente cupro-uranífero de más de 350,000 toneladas, con ley inferior a 0.1% U_3O_8. De este metraje poco menos de la mitad había sido labrado con anterioridad con motivo de explotación de cobre. En este lugar al igual que en Los Amoles, el muestreo sistemático llevado de 2 a 4 mts. en los laboríos ha servido para evaluar el yacimiento con el tonelaje que actualmente se ha mencionado.

c) Sierra de Gomez.- Los yacimientos uraníferos ubicados en la unidad estructural conocida como Sierra de Gómez, la cual es parte de un anticlinorum integrado por calizas de la Formación Georgetown del Cretácico Inferior, dentro del Geosinclinal Mexicano, se localiza a 22 kilómetros al noreste de Villa Aldama, Chih. La mineralización es principalmente carnotita y tyuyamunita y está controlada por fracturas y planos de estratificación. Los estudios geológico-radiométricos y los barrenos de diamante, además de un intenso laborío minero, han permitido la extracción de aproximadamente 20,000 toneladas de 0.4% de U_3O_8, estimándose que cuando menos unas 15,000 toneladas pueden aún recuperarse de la Sierra de Gómez, propiamente hablando, y de las localidades circunvecinas que participan de una geología similar. Las obras mineras hasta ahora realizadas en esa región dentro del Municipio de Villa Aldama, suman alrededor de 4,500 metros lineales.

d) La Sierra de La Cal.- En esta unidad estructural situada 15 kilómetros al norte de la población de Nazas, del Estado de Durango, se tiene un importante yacimiento con mineral secundario de carnotita y tyuyamunita, el cual se aloja en fracturas de un anticlinal asimétrico integrado por rocas del Cretácico Inferior, que están afectadas por intrusivos del Terciario, produciendo zonas irregulares brechadas, que son en parte control de la mineralización. Merced a un mapeo detallado geológico-radiométrico y con la ayuda de barrenos de diamante, se ha podido conocer una caprichosa irregularidad de cuerpos mineralizados en el subsuelo, los cuales se han verificado con un laborío minero bastante extenso que ha abarcado aproximadamente 3,000 metros lineales. Las reservas de esta localidad, entre positivo, probable y posible pasan de 500,000 toneladas de mineral secundario uranífero, con ley cercana al 0.1% U_3O_8.

6. La zona radiactiva más profunda bajo la superficie se encuentra a 220 metros en la localidad conocida como La Luz del Cobre, del Estado de Sonora. Obviamente una profundidad grande, por ejemplo de 300 metros, para la explotación de un yacimiento uranífero a esa profundidad, plantearía el problema de si es o no, económica, independientemente de que tenga tal ley o tal tonelaje. La profundidad de 1,000 pies en Estados Unidos es económicamente trabajable para gran cantidad de yacimientos a esas profundidades. La exploración de yacimientos de acuerdo con diferentes técnicas, sea que se trate de recuperar mineral a base de trabajos a cielo abierto, o bien con obras subterráneas, es otro factor que influye en la evaluación de yacimientos. En la mayor parte de los yacimientos mexicanos, una porción del mineral radiactivo puede recuperarse con trabajos a cielo abierto y la mayor cantidad , merced a obras subterráneas. Los recursos de mineral radiactivo-

de que se ha hablado, se refieren al suministro disponible para el presente y el futuro. Generalmente las reservas se refieren al mineral de interés inmediato, o de consideraciones a pronto alcance, de tipo económico.

7. Con las mayores aplicaciones del uranio como combustible nuclear y el perfeccionamiento tecnológico para su aprovechamiento en la industria eléctrica, habrán de evaluarse los yacimientos cuyo contenido en U_3O_8 sea inferior al .2 hasta ahora considerado como un standard, y es que si en el presente fuera antieconómico recuperar concentraciones de uranio a partir de reservas con contenido inferior al .1, nada puede decirse de la variación del valor intrínseco y potencial en el futuro. Por lo que respecta a los yacimientos de México ("La Luz del Cobre", en Sonora; Sierra de "La Cal", en Durango) que son de baja ley, las reservas de los mismos son potencialmente un patrimonio dirigido a garantizar una autodependencia de combustible nuclear en el tiempo oportuno futuro, dentro de los próximos años. La superficie relativamente escasa que se ha cubierto hasta estos momentos en la exploración del uranio en México, y los descubrimientos que se han realizado por la Comisión, da bases justificadas para proyectar, sin embargo, que se tendrán depósitos de reservas substanciales con leyes promedio superiores a las que actualmente se han considerado.

8. Aunque las cantidades de mineral radiactivo conocidas en México hasta la fecha no son lo suficientemente amplias para contar por un número de años con un apreciable contenido uranífero, a fin de poder recuperar concentrados, obtener uranio metálico y producir energía en cantidades de escala industrial, sí puede decirse sin embargo, que las técnicas y los resultados de exploración llevados a cabo por la Comisión Nacional de Energía Nuclear en el país, han dado resultados que son base para continuar explorando en áreas favorables y reunir tonelajes de mucha mayor consideración.

a) El valor de las reservas de mineral de uranio de México, es una cantidad superior al monto invertido por concepto de todas las exploraciones realizadas en la República. Si se concede que el valor actual de U_3O_8 en concentrados es entre 6 y 8 dólares la libra, o sea entre $ 165.00 M.N. y $ 222.00 M. N. el kilogramo, existe un margen substancial de importancia, considerando que conocer la existencia del mineral radiactivo mexicano en el suelo y en el subsuelo, hasta la fecha, significa en términos generales, una inversión de $ 30.00 M. N. por cada kilogramo contenido en mineral radiactivo. No se han hecho cálculos del monto que representa la explotación, almacenamiento, transporte, trituración y molienda, tratamiento y beneficio del mineral, hasta llegar al concentrado en forma de biuranato de sodio o nitrato de uranilo. Pero en la Luz del Cobre, Sonora, se han hecho trabajos experimentales que permiten apreciar un costo de $ 100.00 M. N. el kilogramo de concentrado de 85% U_3O_8, a partir del mineral puesto en la planta.- Obviamente, si sumamos los precios de explotación (no calculados en este informe) los de exploración y los de beneficio, se preve un resultado inferior al de $ 220.00 M. N. por kilogramo de U_3O_8.

b) Además de ese valor propiamente, saltan otras consideraciones de apreciación en los yacimientos uraníferos de México: científicamente se ha probado que los métodos de exploración adecuados trabajan, y que a la luz de su realización la mayor escala podrían conducir a aumentar los tonelajes. Otro ángulo que se puede considerar ligado a la evaluación, es el que se refiere al abastecimiento de materia prima en la República, para que en forma de combustible nuclear, pueda garantizarse un futuro energético que demandará cada vez mayores requerimientos en un país joven como es el de México, que incrementa su población a razón de 3% anual, y con un desarrollo industrial de magnitudes palpitantes. Por otro lado, la producción energética que actualmente se tiene a costa de los hidrocarburos, permite que se tenga la apreciación de que se utilizarán, dentro de un término razonable, fuentes complementarias que coadyuven a las convencionales en el cuadro energético del país. Por lo tanto, conocer y evaluar los yacimientos de uranio en México, es una labor que está justificada dentro de un número de años, en virtud de la extensión territorial y de las posibilidades tan variables que existen en la ocurrencia de fuentes radiactivas.

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E/CONF.39/A/316/Corr.1
10 Dec.1962
ORIGINAL : ESPAÑOL

CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

C O R R E C C I O N

Las dos mapas que se adjuntan han sido omitidas por error :

(veanse las paginas que siguen)

EXPLICACION

● **REGION URANIFERA**

RESERVAS

POSITIVAS + PROBABLES + POSIBLES			
SIERRA DE SANTA ROSA	5 000 T	0.3	$\%U_3O_8$
MINA LA LUZ DEL COBRE	350 000 T	0.05	$\%U_3O_8$
LOS AMOLES	48 000 T	0.5	$\%U_3O_8$
SIERRA DE GOMEZ	35 000 T	0.4	$\%U_3O_8$
REGION DE OJINAGA	2 000 T	0.3	$\%U_3O_8$
SIERRA DE BERMEJILLO	15 000 T	0.15	$\%U_3O_8$
SIERRA DE LA CAL	400 000 T	0.1	$\%U_3O_8$
GARAME	2 000 T	0.4	$\%U_3O_8$
TLAUCINGO	1 000 T	0.15	$\%U_3O_8$
LOS LAMENTOS	8 000 T	0.15	$\%U_3O_8$
TOTAL	865 000 T	0.117	$\%U_3O_8$

* *T.I.2. Estudio y evaluación de los recursos minerales radiactivos.*

FIGURA I

COMISION NACIONAL DE ENERGIA NUCLEAR

DIRECCION DE EXPLORACIONES

ING. JESUS RUIZ ELIZONDO

COMISION NACIONAL DE ENERGIA NUCLEAR

DESARROLLO MINERO Y ZONA RADIACTIVA EN LA MINA "LOS AMOLES", MUN. DE RAYON, ESTADO DE SONORA.

(COORDENADAS EN METROS)

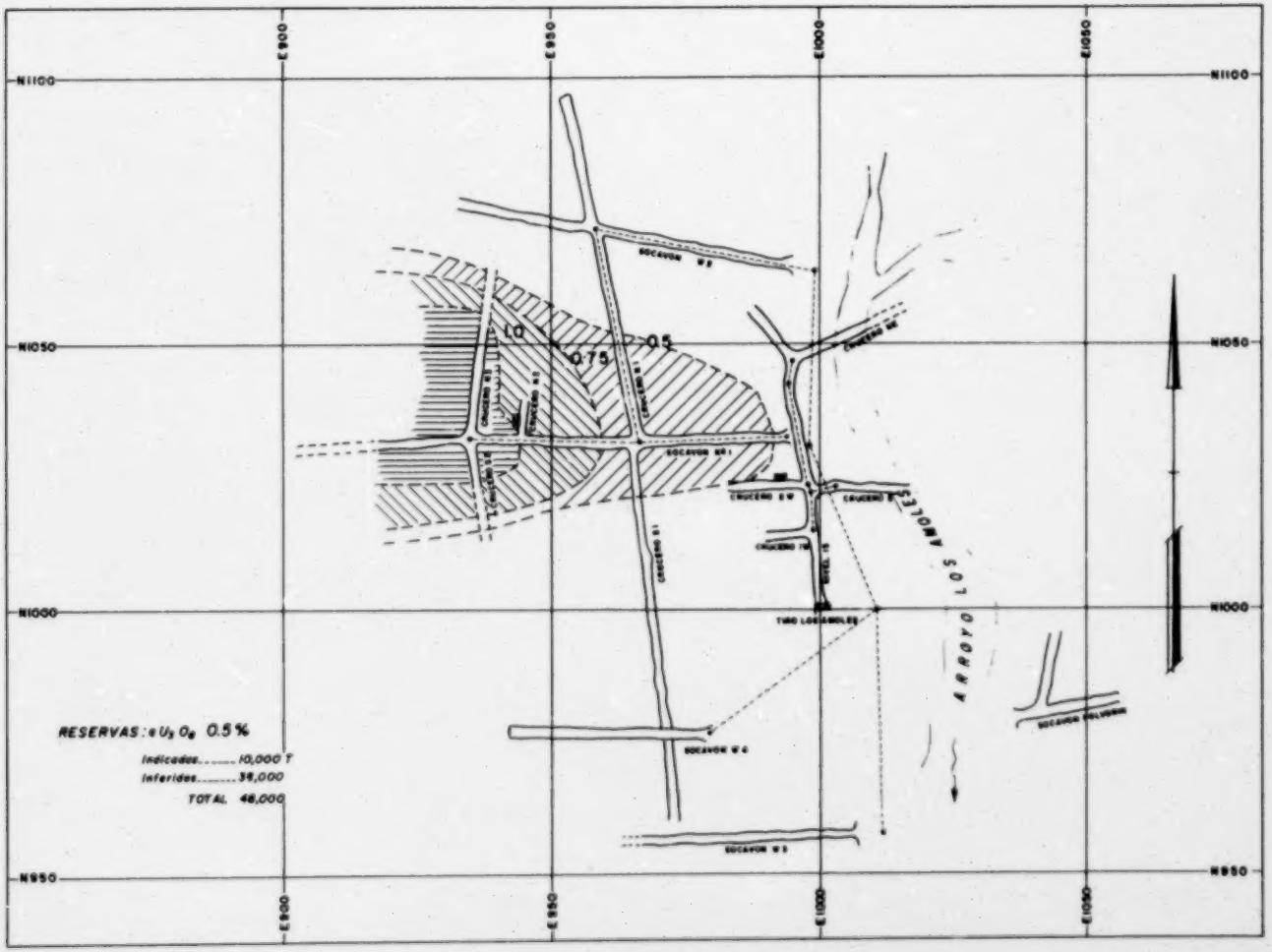

FIGURA II

México, D.F. a 30 de Agosto de 1962

1568 S - Nov. 1962 - 300

NOTES

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GOVERNMENT AS A DYNAMIC AGENT IN MINERAL RESOURCE DEVELOPMENT

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United States Department of the Interior
Washington, D. C.

Introduction

1. For many nations the unlocking of mineral resources represents a major opportunity to stimulate progress for their peoples through the creation of economic wealth. The utilization of a nation's mineral resources can be a determinant of social and industrial progress. The income so derived can make a substantive contribution to material progress and can provide additional means for advancement of the technical skills of the people. Unused, mineral resources contribute nothing to a nation's welfare. Under any political philosophy, government initiative is integral to the maximum utilization of mineral resources in the national interest.

2. Government plays many roles in mineral resource development: Surveyor, scientist, landlord, proprietor, revenue collector, economic regulator, planner, protector of the public welfare, educator, negotiator in international affairs. In these activities the government has a dual responsibility to establish and maintain a stable course for its nation while, at the same time, assuring its responsiveness to changing fundamental conditions. The extent to which government dynamically creates a healthy environment for a minerals industry measures the degree to which indigenous minerals may assist in improving the national standard of living.

3. To raise a nation's standard of living through creation of wealth from mineral resources requires technical and professional competence and investment capital. Most important, government must stimulate and encourage mineral resource development. While minerals are a foundation for modern industry, agriculture, and urban life, it may be noted that some nations have a high degree of economic activity and high living standards with few, if any, mines or oil fields.

4. In a less developed nation the government's part in resource programs is peculiarly important because the usually limited number of persons with managerial and technical talent tend to concentrate in the government, which is the locus of power. Thus the creation of national resource development programs clearly is based upon the wisdom and energy of government. The success any less developed nation attains in creating a prosperous economy based on mineral wealth depends largely upon the intelligent planning and effective implementation of that nation's leadership.

5. To assist such countries in unlocking their natural resources is a challenge to the industrialized nations--a challenge which my Government is doing much to meet. The Department of the Interior, as the prime resource development agency within the United States Government, is pleased to share in this effort.

Exploration and Assessment

6. It is vital for newly created or less developed nations to assess as soon as possible what mineral resources may be available. An initial step in this regard, for which there is much precedent, is the establishment of a state organization

designed to foster and encourage minerals investigations. Such a national service presupposes the availability of scientific specialists and technicians sufficient in number to staff an efficient, even if limited, research agency charged with responsibility for reconnaissance and assessment of the national minerals potential.

7. The United States and many other nations have benefited from establishment of such minerals research agencies. Geological surveys and mining bureaus function effectively in India, Mexico, Canada, Peru, Chile, Japan, Australia, much of Europe, and elsewhere. Since World War II an outstanding contribution has been made in the Philippines where a small but effective mining bureau has been of great assistance. Such service agencies, staffed with competent personnel, have more than paid their way. Even an extensive assessment of mineral resources is only a beginning. It cannot be an absolute inventory, for despite improvements in geological techniques and instrumentation, we can only make educated guesses as to what lies beneath the ground. It is the role of such an agency to constantly improve its estimates of the minerals potential.

8. In many cases, development of mineral deposits and ancillary facilities requires large capital investment. In fact, foreign investment contributed much to the early development of the mineral industry of the United States. Many governments turn to foreign financing in such cases. Peru's Marcona iron deposit was known for years, but the Nation did not benefit from it until foreign financing, encouraged by the Peruvian Government, enabled its development on a large scale. Now the deposit provides a raw material for Peruvian blast furnances, foreign exchange through exports, and, possibly most important of all, training in industrial operations for Peruvian technicians, businessmen, civil servants, and engineers. Such a "creation" of mineral resources through application of capital, technology, and labor obviously benefits the Peruvian people in many ways.

Government's Direct Interest

9. As landlord or proprietor the state determines the development of state-owned resources. These resources may be developed by the state, by private domestic companies on license or concession, by private foreign entities on license or concession, by private companies in cooperation with the state, and possibly in other ways or combinations of effort. The state must provide a program and an incentive for any desired private development. Government also may provide that mineral resources shall be owned and developed by the finder. In most instances the development program should be designed to maintain maximum efficient employment and production, while permitting a reasonable return on invested capital.

Regulation and Revenue Collection

10. The primary long-term goal of national policies affecting mineral resources should be economic betterment of the citizens, and this must be kept constantly in view. Mineral resource development is of questionable value if it does not result in enhancement of living standards, encompassing the provision of adequate food, housing, communications, health facilities, education, and gainful occupation. The extent to which effective development takes place within a reasonable time may depend upon the laws and regulations under which the mineral industry operates. Although a seeking for political goals, without regard for economic gain, occasionally may intervene, all industry should pay its way and contribute through taxation and other means to the national welfare.

11. The government that encourages the accumulation of capital for research, development, and utilization of mineral commodities is taking an essential step in stimulating a sound domestic minerals industry. On the other hand,

government can defeat efforts toward mineral resource development through inequitable taxation, short-sighted tariffs, poorly devised mining laws, difficult legal requirements pertaining to labor and business structure, and a generally unsympathetic attitude.

Planning in the National Interest

12. No single formula applicable to all nations can be devised to encourage minerals development, and the actions any state takes will depend upon its own social, technological, and economic capabilities. Each state, however, can assure that planning of mineral resource development is coordinated with related energy, transportation, agriculture, and education programs, thus spreading costs over a wide base and extending social benefits to more people. It should be emphasized that mineral planning must be coordinated with import and export policies. Imposition of a high import tax on drilling or mining machinery, especially when such equipment is not manufactured within the nation, can inhibit mineral search and development. Export taxes on ores and concentrates should be gauged to economic levels compatible with world markets since many nations compete for trade and few have a product that is unique. Often it is impractical or impossible to process or fabricate mineral raw materials locally, and at times a mineral commodity initially cannot be used to maximum advantage in the producing country. It may be desirable to export such materials with the object of accumulating capital for subsequent industrial development when the nation's economic position warrants the installation of more complex fabricating or manufacturing units.

13. Government has a specific responsibility in resource development in the field of labor. Progress in industrialization requires real incentives to produce for the common welfare. For the individual worker, incentives must embrace opportunity --full opportunity to employ all his capabilities and to achieve recognition through advancement and promotion on the job, and full opportunity for better living for his family and children, including good housing, medical care and sanitation, and education. The worker must share and benefit from industrial effort. There should be recognition of this philosophy at the inception of a resource development program.

14. There is another point that must be emphasized. Throughout the world there is a staggering under-utilization of human skills and capacities. This serious defect must be corrected whenever possible if full advantage is to be taken of industrial development. There are untapped reservoirs of human ingenuity in emerging nations, hidden or dormant creative abilities striving for recognition and use. Basic training in the use of modern tools and equipment, coupled to educational programs designed to stimulate initiative and ingenuity on the part of the individual worker, is the essential method of unlocking these latent possibilities--government must recognize and encourage such endeavor.

15. Inherent hazards in mining can be greatly reduced through safety training, establishment and enforcement of safety codes, and alert supervision and inspection. Also needed is the protection of the health and safety of persons in the vicinity of mining and processing operations. In seeking solutions to such problems, the experience of the United States and many other nations may be helpful.

Technological Education

16. Minerals development requires skilled and educated personnel competent to undertake the unusually difficult and complex assignments inherent to minerals resource investigation and technology. Such personnel will be needed both in research and in production. Most nations, particularly the less developed nations, need outside technical and scientific assistance to some degree. In these days no nation is truly self-sufficient in scientific and technical talent. Establishment or expansion

of technical schools cannot be accomplished overnight, and this certainly is true where the domestic demand for such specialized skills may be limited to a relatively small annual increment of new specialists. Also, because of the need for mineral development concurrent with the strengthening of technical education, and because of the highly specialized nature of this education, it may be best that the schooling of a nation's own citizens in such professions as geology, mining, engineering, and metallurgy be undertaken outside the country. There are many ways that government can act as a dynamic force in expanding the number and improving the quality of technical and professional personnel. Among these in the United States are direct incentives such as grants and loans to students, and contracts, grants, or loans to institutions, and indirect incentives such as adjustments of the tax structure for mineral industries which support supplemental education for their employees.

17. Since resource research and management, be it in forestry, water, minerals, agriculture, or public health, involves extensive training at the post-graduate level, there may be substantial advantage in seeking a regional approach to these problems. Cooperative establishment of education and research centers available to more than one nation, with a faculty and facilities able to meet the requirements of the resource field, might be a satisfactory solution.

International Aspects

18. Governments today have the opportunity to seek assistance in resource development from international agencies and from several nations. The thoughtful and selective use of such assistance can and should provide some of the essential elements needed to initiate mineral resource utilization. A major component of such outside aid can be the provision of assistance in resource surveys and advice on regional development along with accelerated education and training. It must be recognized, however, that technologies from developed countries may not be readily transferable to the less developed countries-adaptive innovation on the part of both nationals and foreigners will be required.

19. Economic mineral deposits are not evenly distributed around the earth. This uneven distribution is a major factor in stimulation of world trade, making the various parts of our world inter-dependent, and this, after all, should be to everyone's advantage. Government has a major role in this situation, developing import and export policies that will encourage the exchange of surplus raw materials, and their processed or manufactured products, for those in short supply domestically.

The Impetus for Development

20. The impetus for mineral resource development in less developed nations may include a seeking for national prestige through industrialization. This prestige factor cannot be ignored, but it can be over weighted. An impressive industrial plant, by itself, cannot improve a nation's economic level and, in fact, may require an expenditure of money, manpower, and material far in excess of its capacity to produce economic benefits.

21. The establishment of a viable minerals industry may become a primary means of stimulating the growth of public utilities, such as transportation and power, and may result in large expansion in markets both for raw materials and fabricated products. But the dominant impetus for resource development should be the desire for a higher standard of living. A minerals industry can well contribute to this objective, providing full, creative opportunity for a nation's people. The extent to which these broad benefits of mineral resource development are realized depends, in large measure, on the implementation of dynamic, practical, and farseeing policies by the government.

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L'importance des cartes topographiques, les bases géodésiques et les méthodes de la photogrammétrie pour leur établissement rapide.

Par les Professeurs F. Kobold et H. Kasper
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1. L'importance des cartes et des plans géographiques.

Les cartes et les plans géographiques sont indispensables pour toute activité technique ayant un rapport quelconque avec les particularités naturelles de la surface terrestre. Ils donnent une image abstraite de cette surface, et non pas une impression directe comme le font les vues photographiques aériennes. Les cartes et les plans se distinguent des vues photographiques aériennes par les caractéristiques suivantes :

- Une carte ou un plan ne reproduit pas simplement les particularités de la surface terrestre visible sur la vue aérienne, mais en donne une sélection judicieuse, en caractérisant les objets et en montrant l'importance de chacun d'eux par le mode de représentation. Alors que dans la vue aérienne, il n'est par exemple pas possible de distinguer un ruisseau d'un chemin, la carte renseigne exactement à ce sujet. Sur la carte figurent en outre des objets qui ne sont pas visibles sur la photographie aérienne, par exemple des routes et des chemins en forêt.

- Les cartes et les plans rendend exactement les distances horizontales, ce qui n'est pas le cas de la photographie, sur laquelle il ne faut en général pas faire de mesures linéaires.

- Les cartes et les plans donnent aussi des indications sur les altitudes et sur le relief du terrain, ce qui n'est point les cas de la photographie.

La prise de vues aériennes d'une région peut être considérée comme une première exploration cartographique. Dans certains cas, les vues suffisent à donner une idée générale d'une contrée, et elles fournissent souvent des informations précieuses sur des particularités du terrain. On appelle interprétation des photos aériennes cette exploitation générale. Ce n'est toutefois que la carte ou le plan qui assurera, conjointement avec l'interprétation de photograp hies aériennes, une connaissance du terrain suffisante pour l'exécution de projets techniques. Plus l'échelle est grande, plus il est possible de donner des détails sur le terrain et ses particularités naturelles ou artificielles. Inversément, l'aspect général et les grands ensembles sont d'autant mieux mis en valeur que l'échelle est plus petite. On parle de cartes lorsque l'échelle de la représentation cartographique du terrain est inférieure à 1 : 10 000, et de plans quand elle est plus grande.

a) Cartes géographiques

Echelles : 1 : 20 000 1 : 50 000 1 : 100 000.

Le relief du terrain est représenté par des courbes de niveau. Les équidistances sont de 10 mètres pour l'échelle 1 : 20 000, 20 mètres pour 1 : 50 000 et 50 mètres pour 1 : 100 000. Les cartes géographiques servent à :

i) la représentation synoptique du terrain lui-même ou de données en rapport avec celui-ci, par exemple la densité de la population, l'habitation, les voies de communication, les forêts, la géologie, l'hydrologie, les types de sol, l'irrigation.

ii) l'étude générale de projets techniques de tous genres, tels que routes et voies ferrées, systèmes d'irrigation et de drainage, usines hydro-électriques. On dessine sur des cartes de ce genre le tracé général des ouvrages.

b) Plans

Echelles : 1 : 500, 1 : 1000, 1 : 2000,
1 : 5000, 1 : 10 000.

Selon le but visé, on renonce parfois à la représentation du relief dans les plans à très grande échelle (1 : 500 à 1 : 2000) (levés cadastraux). En revanche, les plans aux échelles 1 : 5000 et 1 : 10 000 contiennent toujours des courbes de niveau, l'équidistance étant respectivement de 5 et de 10 mètres dans la plupart des cas. En règle générale, l'équidistance est de 1 mètres pour les plans au 1 : 1000 et de 2 mètres pour ceux au 1 : 2000.

Les plans géographiques servent à :

i) représenter d'une façon claire les détails d'un

ouvrage à construire, en particulier à fixer les tracés d'axes de construction pour des routes, des voies ferrées, des canaux, et à déterminer l'emplacement le plus favorable pour les centrales et d'autres éléments importants d'ouvrages hydro-électriques.

ii) représenter des particularités telles que des canalisations, des sources, des conduites aériennes ou souterraines et des ouvrages de tout genre.

Les cartes et les plans sont l'une des bases les plus importantes pour la mise en valeur économique et technique d'un territoire et l'utilisation du sol pour l'agriculture. Sans une étude très exacte du terrain à l'aide de vues aériennes, de cartes et de plans, il n'est pas possible de trouver pour un projet technique la solution la meilleure par rapport aux conditions topographiques.

c) Bases géodésiques

Pour le jalonnement de certains ouvrages sur le terrain, par exemples de galeries pour des ouvrages hydro-électriques, les cartes et les plans ne suffisent pas comme base topographique. Des points fixes doivent être établis sur le terrain, à des intervalles allant de quelques centaines de mètres à plusieurs kilomètres, et avec une précision de quelques centimètres. Dans les régions où l'on peut prévoir des travaux futurs, il faut donc non seulement lever des cartes et des plans, mais encore observer et calculer un réseau de points fixes.

2. La méthode du levé photogrammétrique

Cette méthode consiste à dessiner des cartes et des plans précis en partant de vues aériennes, à l'aide d'appareils de restitution. Elle a de plus en plus remplacé les procédés plus anciens, qui demandent un intense travail sur le terrain. Sans la photogrammétrie, il ne serait pas possible de réaliser dans un avenir relativement proche le grand programme cartographique, dont l'exécution est urgente aussi bien dans les pays industrialisés que dans les pays encore en voie de développement.

Toutefois, la photogrammétrie exige elle aussi un travail sur le terrain. Il est en effet nécessaire de mesurer sur le sol des points fixes. Ces points doivent être reconnaissable sur les photographies aériennes, de façon que les vues, prises d'un avion, dont la position n'est pas connue, puissent être orientées exactement.

La densité et la précision de ces points dépendent de l'échelle des cartes et des plans. Plus l'échelle est petite

et moindre est le nombre des points nécessaires. Le degré d'exactitude doit être choisi au moins de manière telle que les points reportés sur le plan ou la carte puissent être considérés comme pratiquement exacts. Il est aujourd'hui facile d'arriver à une grande exactitude, et il faut d'autant plus y tendre que ces points devraient servir non seulement à l'établissement de cartes, mais éventuellement, par la suite, à d'autres buts. Pour une carte à l'échelle 1 : 50 000 ou 1 : 100 000, on déterminera tous les 30 kilomètres un groupe de points avec une exactitude d'environ 1 mètre. Si l'on veut en revanche faire un plan à l'échelle 1 : 2000, les distances entre les groupes de points ne devraient pas dépasser 3 kilomètres, et la précision devrait être d'environ 5 cm.

3. Méthodes pour déterminer les points géodésiques

a) Méthodes astronomiques

Des observations d'étoiles servent à la détermination de la latitude et de la longitude d'un point, ainsi que de l'azimut d'un point à un autre. Ces méthodes sont longues et difficiles et n'entrent en considération que pour quelques points principaux d'un réseau. Même avec des observations très exactes, de grands écarts entre la position calculée et le point réel sont possibles.

b) Mesures de distances et d'angles

La mesure directe de distances avec des lattes, des rubans et des fils n'entre plus qu'exceptionnellement en ligne de compte. Pour mesurer rapidement et avec précision des distances allant de quelques centaines de mètres à 40 kilomètres, les appareils électroniques développés au cours de ces dernières années ont fait leurs preuves. On arrive à une précision de moins d'un décimètre pour des distances atteignant 40 kilomètres.

Pour mesurer les angles, on utilise le théodolite. Ces théodolites de haute précision permettent aujourd'hui une exactitude d'une seconde. Ainsi donc, la précision relative est à peu près la même pour les distances et pour les angles.

c) Triangulation

Le procédé de la triangulation consiste à mesurer une distance, puis à déterminer tous les points du réseau uniquement par les angles. La triangulation est le moyen classique et elle atteind une exactitude assez grande, mais exige un gros travail et présente des difficultés en terrain plat ou très couvert.

d) Trilatération

Dans le procédé de la trilatération, on ne mesure que des distances. Cette méthode, qui n'est possible que depuis

l'introduction des appareils électroniques, atteint le même degré d'exactitude que la triangulation. De même que pour celle-ci, l'établissement d'un bon réseau de trilatération peut être difficile selon la nature du terrain.

e) Procédés combinés

L'expérience de ces dernières années a montrée que c'était en combinant la mesure des distances et celle des angles que l'on parvenait à établier le plus rapidement des bases géodésiques utilisables. Là aussi, il est possible d'utiliser des réseau de triangles, mais souvent on se contente de cheminements assez denses.

f) Détermination des altitudes

C'est la combination de nivellement géométriques et trigonométriques qui aboutit le plus rapidement au résultat recherché.

4. Le procédé de la photogrammétrie aérienne

Pour projeter et établiser un réseau de voies de communication, mettre en valeur les ressources forestières et agricoles d'une manière intensive et dans le cadre d'un plan, exploiter les richesses du sous-sol, créer des industries, utiliser les forces hydrauliques, de même que pour les plans d'extension des villes, la construction d'ensembles d'habitations et de ports, on préparera par la méthode photogrammétrique les documents suivants :

a) Les photographies aériennes, premier élément permettant de reconnaître le terrain (interprétation photographique) et d'établir toutes les cartes et tous les plans. L'interprétation des photographies et l'établissement des cartes sera d'autant plus économique que la qualité sera meilleure.

b) Comme vue d'ensemble pour des projets généraux, des cartes à petite échelle, en particulier au 1 : 100 000, avec courbes de niveau.

c) Pour les zones les plus importantes d'un projet :

   i) Les photo-plans (mosaïques), à l'échelle 1 : 25 000;

   ii) les plans de situation à grande échelle, 1 : 10 000, avec courbes de niveau.

d) Pour les projets de détail :

   i) Les plans à courbes de niveau, au 1 : 1000 ;

   ii) levés de profils.

5. Appareils pour la prise des vues aériennes

Pour obtenir des vues aériennes de haute qualité, on construit en Suivve des appareils de prises de vue automatiques (chambres aériennes) à grand rendement.

a) Elles sont équipées :

   i) pour les prises de vues à petite échelle, d'un objectif super-grand-angulaire (angle de champ): 120°; distance focale: 9 cm) ;

   ii) pour les prises de vues à échelle moyenne et à grande échelle, d'un objectif grand-angulaire (angle de champ: 90°; distance focale: 15 cm).

b) Le format standard des photographies est de 23x23 cm (9 x 9").

c) Les vues sont prises sur un film panchromatique, le plus souvent avec un filtre jaune.

d) Pour des prises de vues à petite échelle, il est recommandé d'employer des films sensibles à l'infrarouge et des filtres rouges.

6. Dispositions pour la prise de vues

a) Il est opportun d'employer des avions spéciaux, dans lesquels on peut placer simultanement les deux types de chambres.

b) Le système le plus économique et le plus simple est la prise de vue verticales.

c) Le terrain à relever est survolé en ligne droite. Les vues d'une bande de terrain survolée doivent se recouvrir à 60%, dans des cas spéciaux à 80%. Les bandes parallèles se recouvrent à 30%. Le recouvrement longitudinal des vues est réglé automatiquement.

7. Echelle des vues et hauteur de vol

Les hauteurs de vol seront choisies en fonction de l'échelle désirée pour les p hotographies.

a) Pour établir des cartes à petite échelle, ou à échelle moyenne, les échelles des photographies correspondant à la figure1sont recommandées. Cette figure indique aussi les hauteurs de vol correspondantes pour les deux types de chambres aériennes.

b) Pour les cartes à grande échelle et les profils exacts, il est indiqué de choisir les échelles des photographies conformément à la figure 2. Pour ces prises de vue, on n'utilisera que la chambre avec un angle de champ de 90°.

8. Interprétation des photographies

Pour interpréter les photographies aériennes, on emploie:

a) Des plaques diapositives sans agrandissement et des photographies normales, copiées avec compensation électronique des contrastes ombre-lumière ;

b) des agrandissements des images aériennes (jusqu'à 6 fois). L'observation est faite à l'aide de stéréoscopes grossissants à miroirs, permettant de voir en relief le terrain reproduit sur deux photographies voisines.

9. Etablissement de photo-plans (mosaïques)

Les assemblages sont composés, pour un terrain plat ou onduleux, à partir d'images aériennes redressées, qui sont collées les unes aux autres avec le minimum d'intervalles. Le redressement photographique est effectué dans des redresseurs spéciaux. Comme bases géodésiques de redressement, on utilise des cartes à petite échelle agrandies ou la triangulation radiale. Ce procédé s'apprend facilement et aboutit rapidement à de bons résultats.

10. Cartes à petite échelle avec courbes de niveau

a) Pour augmenter la densité du réseau des points géodésiques, on se sert de la triangulation aérienne par blocs. Elle consiste à orienter stéréoscopiquement deux photographies consécutives d'une bande de vues aériennes et à réunir des bandes de photographies en un bloc. Ce travail est effectué dans un appareil universel de restitution photogrammétrique. En Suisse, on emploie pour prises de vues avec un angle de champ très grand, l'autographe super-grand-angulaire Wild A 9 (Fig.3).

i) Les coordonnées instrumentales des points de report d'un modèle à un autre peuvent être enregistrées électriquement.

ii) Pour garantir l'identité des points de report dans les bandes de photographies voisines, on les marque sur les plaques diapositives, avant l'aérotriangulation, avec un appareil stéréoscopique pour le transport des points.

iii) Les plaques diapositives sont préparées dans un transformateur d'images, dans lequel l'influence de la courbure terrestre et la distortion résiduelle de l'objectif sont compensées optiquement.

b) Le passage à la carte, appelé la restitution, est faite de préférence dans des appareils simples. En Suisse, il existe trois types d'appareils de ce genre: les aviographes Wild B 8 et B 9 et le PG 2 de Kern.

11. Etablissement de plans à grand échelle

Les procédés sont généralement connus. Voici l'exactitude moyenne des altitudes qui peut être réalisée en terrain non boisé:

± 1/10 000 de la hauteur de vol pour des points signalisés ;

± 2/10 000 de la hauteur de vol pour des points du terrain bien définis ;

± 3/10 000 de la hauteur de vol pour des courbes de niveau.

Pour les échelles des prises de vue recommandées dans la figure, l'exactitude de la situation correspond à l'exactitude normale du dessin.

12. Levé des profils - Enregistrement automatique

Pour des travaux d'ingénieur, la mesure des profils en long et en travers est en général préférable à un plan avec courbes de niveau. Pour lever les profils, on emploie des instruments, appelés profiloscopes, que l'on adapte aux restituteurs photogrammétriques. Ils permettent de lever les profils par points. Les données du profil sont enregistrées électriquement en clair, sur bandes ou cartes perforées.

13. Transformation automatique des données

Les coordonnées des modèles enregistrées lors de l'aérotriangulation et lors de levé photogrammétrique de profils peuvent être transformées immédiatement en coordonnées du pays ou en points de référence quelconques du profil, au moyen de bandes ou de cartes perforées.

14. Formation du personnel

La formation de personnel dirigeant soit pour les travaux photogrammétriques, soit pour l'élaboration des bases géodésiques peut avoir lieu en Suisse à l'Institut de Géodésie et de Photogrammétrie de l'Ecole Polytechnique Fédérale, à Zurich:

a) par des études complètes d'ingénieur topographe, d'une durée de 4 ans ;

b) lors de cours spéciaux organisés dans le cadre de la coopération technique internationale.

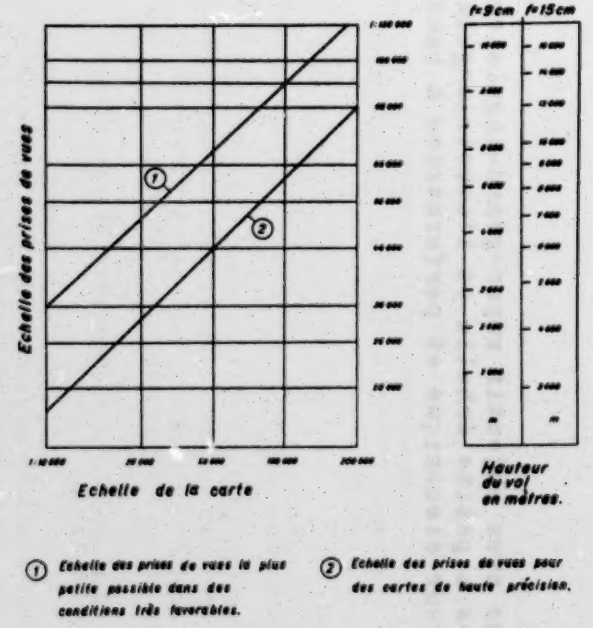
f=9cm f=15cm
Echelle des prises de vues
Echelle de la carte
Hauteur du vol en mètres.
① Echelle des prises de vues la plus petite possible dans des conditions très favorables.
② Echelle des prises de vues pour des cartes de haute précision.

Fig. 1 Graphique, montrant les relations entre l'échelle de la carte, l'échelle de la photographie et la hauteur du vol

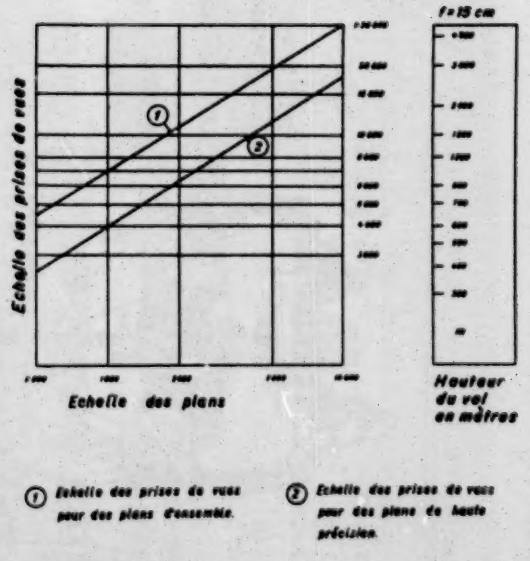
f=15 cm
Echelle des prises de vues
Echelle des plans
Hauteur du vol en mètres
① Echelle des prises de vues pour des plans d'ensemble.
② Echelle des prises de vues pour des plans de haute précision.

Fig. 2 Graphique, montrant les relations entre l'échelle du plan, l'échelle de la photographie et la hauteur du vol

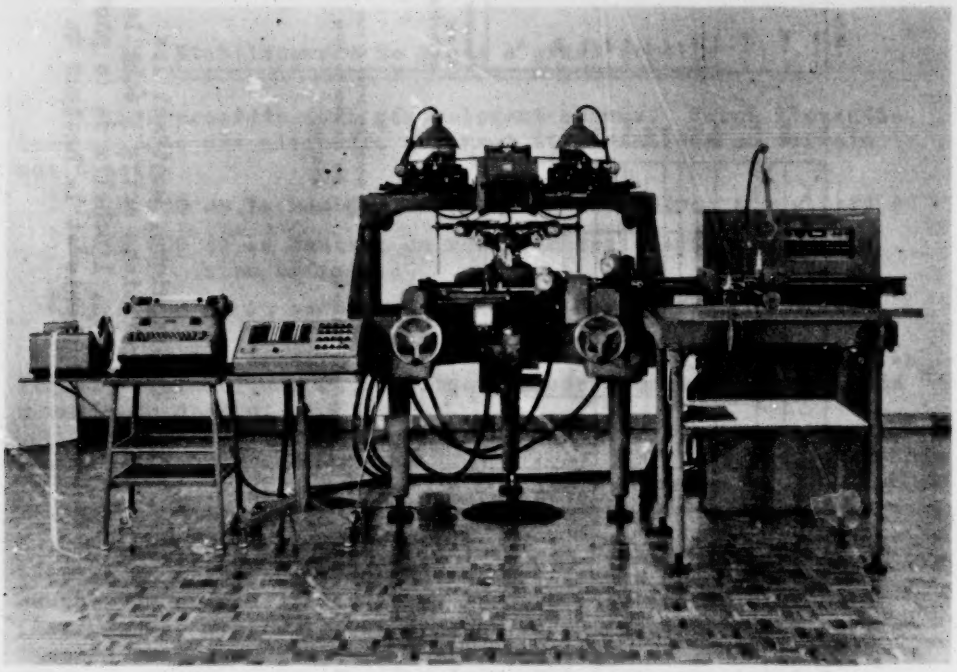

Fig. 3 Autographe avec objectif super-grand-angulaire pour des cartes à petite échelle et l'aerotriangulation, enrégistreur électrique et perforatrice à bandes

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E/CONF.39/A/319
2 Nov.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A. 3. 4. 2

Italy

THE DEMINERALIZATION OF SALINE WATER WITH SOLAR ENERGY

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

The demineralisation of saline water with solar energy

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1. The future of many less-developed areas of the world depends in part on the availability of fresh water. This term will here be used to indicate water containing less than 1000 p.p.m. of dissolved salts. There is however a very large number of different conditions and needs: for this reason the study of the ways for giving fresh water to arid zones requires many different approaches.

2. In order to satisfy the needs of an industrial area or of a large community it is necessary either to make hydraulic works and networks or, if only saline water is available, to use demineralization processes requiring cheap fuels or nuclear energy. This can be made in large plants and presently techniques are available which allow to foresee the future developments.

3. On the other side there is a large number of little communities or isolated country houses having available only water containing more than 1000 p.p.m. of salts and in this case the use of solar distillation may prove successful for obtaining little amounts of water for drinking or domestic uses. The problem of the manufacture of efficient and simple solar stills has been studied in many laboratories for at least ten years (1). It is now possible to summarize such results.

4. First of all it is necessary to clear that at the present the solar stills cannot be used in large plants, for producing ~~w~~ fresh water in amounts of the order of thousands cubic meters per day. In fact in the single-effect solar stills the water production in favourable conditions is of the order of 4 liters/(sq.meter)(day), with an yearly average of 1 cubic meter/sq.meter. In these conditions the production of 1 cubic meter of distilled water per day requires a collecting surface of about 250 sq.meters. If multiple-effect stills would be developed - at expenses of simplicity and cost - this figure might be reduced to 50 sq.meters per cubic meter per day.

5. So far but few attempts have been made to build large scale solar stills; one of these has been designed and built by Löf (2)(3)(4); the second is a project of a solar still with a production of about

1 thousand tons per day, now yet in the laboratory scale, developed in the University of Arizona at Tucson (5). On the contrary there is an immediate field of application for little solar stills for giving water to families or little communities in arid zones. The solar stills for these communities should be manufactured in place, using local materials, following the design lines which have been tested in the past years in various laboratories in the world. The dimensions of such stills may range between 1 and 100 sq.meters of collecting surface.

6. In the author's opinion the success of the solar stills depends largely on their simplicity in design and cheapness, also at expenses of the water yield. An increase of water yield does not pay if is obtained with sacrifice of simplicity, through introduction of auxiliary equipments or of more costly materials. In fact the great advantage of the solar stills is the minimum maintenance they required, derived by the fact that there is no movable part or mechanism. Also the life of the stills seems of secondary importance if the stills can be manufactured in place with local materials. In any way a minimum availability of mechanical shops and facilities and of building materials is necessary.

7. For the manufacture of single-effect solar stills essentially few elements are necessary. Such elements can be assembled in a large number of different ways (6) and can be made with a large number of different materials. The still must essentially contain:

(a) one cover, transparent to solar radiation and opaque to infrared radiation, which is generally used also as an heat exchanger and condensing surface: this condensing surface is surrounded by a little channel for the collection of the distilled water;

(b) one tray or pad exposed to the solar radiation and containing the saline water to be distilled: it must be blackened to increase the solar energy absorption;

(c) one insulation under the tray or pad, for reducing the heat losses; such insulation may also be given by a layer of still air.

Because of the large number of practical solutions which can be given to the assembling of a solar still, the development of such still must be considered, at the present, a technological, rather than a scientific, problem.

8. There is yet one area of scientific interest, namely the study of the thermodynamics of the solar distillation. At the writer's knowledge there are at least three different approaches to this treatment, one by Telkes (7)(8)(9), a second by Baum (10) and the third by workers at the Georgia Institute of Technology (11).

9. The scientific studies and the experimental work so far available have indicated the lines for the economic and efficient manufacture of solar stills and some designs are now available. The manufacture of solar stills and their field use depend on the cost and availability of materials, labor, shop facilities, etc. It seems reasonable to foresee that the manufacture near the

installation site will be preferred to the manufacture in industrialized area and the shipment to users.

10. The solar stills can be manufactured mainly following two ~~designs~~ designs.

(a) The type of solar stills shown in Fig. 1 can be assembled in units of about 1 or 2 sq.meters of collecting area, is very simple and requires a minimum of labor and facilities. This design has been tested in various forms by many laboratories (12)(13)(14)(15) and has been found satisfactory. In this Institute we are manufacturing such little units (Solar still model No. 8) in order to collect accurate data on the cost and the eff. of the still.

(b) The concrete type of solar still, designed for being placed on the roof of the country houses as structural element of the house itself (Fig. 2). One experimental still of this design (Solar still model No. 5) was tested in this Institute years ago (1)(16). According to this design the saline water is pumped in the trays and the distilled water flows by gravity in a tank into the house. For the field application of this model it is necessary to solve some constructive problems. The water in the tray, in fact, reaches a temperature as high as 70-75°C and the concrete layer easily breaks and water losses occur; difficulties are also encountered in the blackening and insulation of the concrete layer of the tray. Probably it will be easier to manufacture structural ~~one~~ elements of molded black plastic material. Fig. 3 shows an example of the section of such elements. They might be placed on a layer of insulating material, on the roof of the building.

11. For the various parts of both types of solar stills various building materials can be used but attention must be directed to the most easily available, local and cheap materials, like iron ~~sh~~ sheets, glass, wood, black paints. Galvanic treatments for blackening the iron sheets must be preferred but they seem hardly applicable in the field. There are many interesting designs based on the use of plastic materials, with the advantage of rather low cost and ~~w~~ weight, but, in the writer's opinion, they require mechanical complications or auxiliary equipments which are too troublesome for an immediate field application. They probably will be successful after further developments and new inventions.

12. The success of solar stills depends in large part by the efforts in order to educate the users to their best use; the distilled water is unpleasant to drink and it is generally necessary to readjust its taste with salts and gases.

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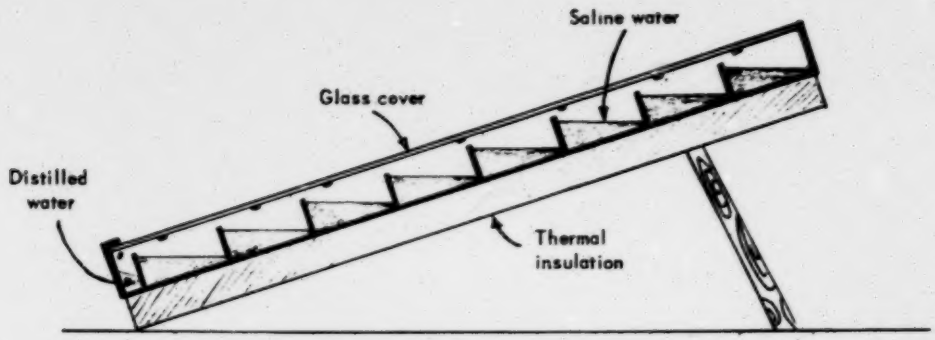

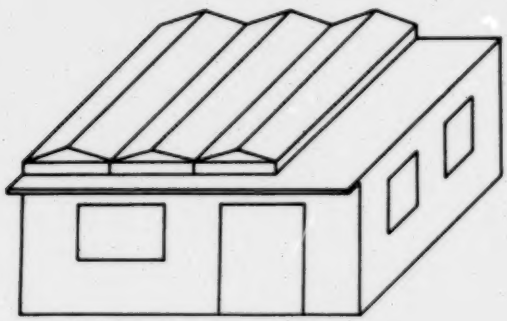

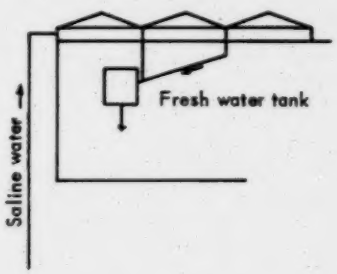

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E/CONF.39/A/320
2 Nov.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A. 4. 2. 5

Italy

GEOTHERMAL ENERGY EXPLORATION

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Comitato Nazionale
per l'Energia Nucleare

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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GEOTHERMAL ENERGY EXPLORATION

by
G. FACCA.
Comitato Nazionale per l'Energia Nucleare.

1. - Geothermal energy : a large source of low cost energy.

Temperature surveys of deep wells and deep mines indicate large differences in temperature gradients in the earth's crust. Temperature gradients vary both in the vertical and in the horizontal. In the vertical, the temperature increases with the depth at a roughly average rate of 1 °C per 27-60 m in the sedimentary basins; but in determined areas this value - the reciprocal of the geothermal gradient - can be as high as 1 °C per few meters. Such areas are defined as hypergeothermal areas. The heat's flow can be very large also at shallow depths.

The energy of the hyperthermal areas can be exploited, and actually it is exploited in different regions of the world. Natural heat is a large and very cheap source of energy and the geothermal industry overpassed the initial experimental phases in the last years; a geothermal power plant - as well as other geothermal prospects - can now be considered as an usual prospect, involving no more risks than the average mineral industrial prospects.

The natural heat of the hypergeothermal areas is exploited by drilling a suitable number of wells at a depth between 300 m and 2000 m. The wells can produce three kinds of exploitable fluids: overheated steam, steam mixed with boiling water and hot water.

The wells producing overheated steam and steam mixed with boiling water are currently exploited for the production of electric power. The hot-water wells are exploited for heating purposes and actually they are of less industrial significance, but we must remember that also hot water can produce electric power.

The natural steam can be admitted directly into the turbine-generator units exhausting into the atmosphere (non condensing turbine) or into a vacuum created by condensing the steam in a condenser just after it leaves the turbine (condensing turbine).

When the natural steam, as produced by the wells, is dirty or mixed with a large amount of non-condensable gas, the steam passes in a heat exchanger where steam is generated from condensate water. This "secondary steam" is fed into the turbines.

Various geothermal fields are exploited in the world at present; many others are known in a number of countries and could be developed in a short time.

The three major operating plants are: Larderello (Italy), which produces yearly 2,3 billions of kWh (year 1962); Wairakei (New Zealand), which has been generating power since November 1958 and where a 69 MW plant was completed in 1960 with additional 123 MW to be operating in 1963; The Geysers (California), which is producing power since June 1960 by a 12,5 MW plant, that will be doubled in 1963.

Other minor plants are operating or have been planned in different countries: in Monte Amiata (Italy), in Pathé (Mexico) a turbine of 3.500 KW, in Katanga (Congo); in Kamchatka (U.R.S.S.).

In Japan, Chile, El Salvador, Kenya, exploration and drilling are under way. Important exploration works are currently conducted or anticipated in Italy, New Zealand, U.R.S.S. and U.S.A..

We think that the largely delayed expansion of the geothermal industry will take place in the near future. The production of electric energy from the geothermal fields already in operation will augment, namely in Larderello, Wairakei and The Geysers. Drilling will be more active in various known fields and the building of power plants will follow as soon as the steam production will reach a convenient figure.

The main reasons for such a confidence are three:

1. - A few years ago, geothermal energy was largely ignored or considered an exceptional event; now, it is a common topic of scientific and industrial information.

2. - Great progress has been registered in all phases of the geothermal science, from exploration to production; substantial reduction of cost and risks have been already accomplished.

3. - The cost of the geothermal KWh is no more a matter of guessing; the experience obtained by the three large plants operating for years authorizes us to calculate in advance the expenses and the production costs in a new field with errors of the same order as in a new oil field.

The kWh cost in Larderello is about 3-4 mills ($ USA); in Wairakei, 4.5 mills and it will probably be reduced.

The actual cost of the hydroelectric and thermal kwh produced by the largest power plant varies from 4 to 10 mills. The lower figures are those of some privileged hydroelectric power plants.

It is no doubt that the geothermal energy is a large source of very low cost energy, and possibly the lowest cost energy now available.

2. - Three geothermal fields: Larderello, Wairakei, The Geysers.

A very brief description of the three main fields now in exploitation will give a better understanding to the reader.

a.- Larderello. Larderello lies in Tuscany (Italy), west of Siena, halfway between Siena and the Thyrrenian Sea. It was known for centuries for its hot water and steam jets temperature from 100° to 190° C,(average pressure 5 atm),utilized for the boron industry.

In 1905, the first power plant working with geothermal energy ignited 5 bulbs; large industrial electric development occured between the two World Wars; after World War II, the chemical production at Larderello was economically negligible and the electric production overwhelming.

The geology is summarized in the cross-section of fig. 1. The basement is quartzitic and anagenetic; follows an ingressive, Upper Triassic, evaporitic-dolomitic series, with high porosity and permeability. It is the steam producing series.

The evaporitic series is unconformably overlain by a flysch-like, shaly, impervious series, locally called 'Argille Scagliose", of Upper Cretaceous-Lower Miocene age.

Nearly all Italian geologists retain that the Argille Scagliose Series is allochtonous; this is not the place to discuss the point, because its significance in the comprehension of the geothermal field is limited. We limit us to point out the different structural behaviour of the upper impervious series in comparison with the lower evaporitic and dolomitic reservoir series. The former is plastic and its reactions to the basement's movements are of the gravitational tectonic type, whereas the lower, more rigid series presents a fault-block structure.

As a consequence, the structure of the producing series can not be inferred from the structure of the Argille Scagliose Series. The fault and fracture areas can be detected only by geophysical surveying and by drilling.

Owing to the space limitation, we cannot give a satisfactory geological description.

We can only point out some interesting geological features of the Larderello field:
1. - In the Larderello area, recent volcanoes do not exist. The abnormal heat flow is provided by a magma stock laying at unknown depth.

2. - The temperature at the top of the producing series is over 200°C and does not sensibly increase with depth in the pervious series. This evidence strongly indicates convection currents in the waters of the producing series.

3. - Hot waters, steam jets and other surface signs of hyperthermal conditions occur near the out-crops of the lower pervious series or where the Flysch series has a very limited thickness. No industrial steam production is recorded where the producing series out-crops. From this and many other evidences, we can safety conclude that an impervious cover is a sine-qua-non condition in the natural superheated steam production.

4. - A great number of geologists believed in the past that the steam was separated by a granitic cooling magma stock and fed trough faults in the producing anhydritic series. They believed also that the producing series contained steam. In the very last past years, this view was consistently proved untenable. The producing series contains meteoric water with the temperature not over the boiling point corresponding to the hydraulic pressure.

A limited amount of magmatic fluids is still postulated by some Authors, who explain the superheating in such a manner.

Tonani and the present writer offered different explication of this intriguing point.

5. - Fig. 2 indicates that scattered areas are at present exploited in the Larderello geothermal field. Three wells recently drilled outside those areas are very good producers; they offer evidence that the true possibilities of the Larderello field are not yet entirely recognized. We can suspect that the field is many times larger than believed; the last successful wells open a new phase in the Larderello field exploration.

The present writer believes that any area of the Larderello region, where we can reasonably suspect that the Anhydritic Series lies at a depth not exceeding 1500-2000 m and is pervious, is a drillable prospect.

The Mount Amiata field lies about 60 km southeastward of Larderello. The geological series and structure are nearly the same as in the Larderello field.

In two points, however, the Monte Amiata field differs from the Larderello field.

First, in Monte Amiata, surface signs of abnormal heat are limited to some hot sources (20°-50°C) CO2 and H2 S mofettes and mercury ore.

Second, Mount Amiata is an extinct quaternary volcano of the acide type, with an extensive ignimbrite cover.

The marine Pliocene sediments occur at 900 m elevation and give evidence of very recent tectonic activity, related to the upward movement of a magmatic mass, now cooling near the surface, but in any case at considerable depth.

b. - Wairakei. The Wairakei geothermal field lies south-east of the Bay of Plenty, in the Northern Island (New Zealand). It is a volcanic region 240 km in length, from the center of the island to the Bay of Plenty. Structurally, it is a recent graben filled mainly by vulcanites.

Two andesitic volcanoes, Ruapehu and White Island, are active at each end of the graben; other active basic volcanoes and recently active rhyolite domes dot the graben.

Wairakei field is a complexely faulted horst in the major graben of the volcanic district. But we must point out that the hyperthermal area in the Waiora Aquifer is not limited to the top of the structure: also the depression on both flanks of the horst are productive.

The geothermal exploration and exploitation history in New Zealand is characterized by close and efficient relations between science and industry from the very beginning. The precious experience thus gained has been communicated in a remarkable series of papers, of uppermost importance for the progress of the geothermal science.

In occasion of the U.N. Conference on New Sources of Energy (Rome, August 1961), New Zealand presented a large number of papers, covering every geothermal detail.

Many previous important contributions were published by the "New Zealand Journal of Geology and Geophysics", the N.Z. Department of Scientific and industrial Research Bull., N.Z. Geol. Surv. Bull. and N.Z. Engineering.

More important data are resumed here.

Wairakei has (1961 data) 26 wells on production; 26 more will be on production in 1963. The New Zealand Government authorized an installation of 192 MW of plant, of which the first stage (69 MW) was completed in March 1960. Tentative plans have been prepared for later extending the scheme to a total installated capacity of 282 MW (Armstead, 1961).

"The first plant (69 MW) makes use of bore steam only and employs seven small turbo-alternators of approximately 6 1/2 MW and 11 MW ratings. The second stage (123 MW), now under construction, will introduce to a limited extent the use of hot water in addition to bore steam; it will be also partly served by larger (30 MW) turbo-alternators" (Armstead 1961).

Initial drilling commenced in 1950 and electric power was supplied to the North Island Grid in November 1958.

Temperatures range between 200° and 260°C.

Bottom diameter of the holes is 7 5/8", average depth 1000 m.

A casing is cemented in the lacustrine mudstone series; a suspended liner (6 5/8" or 6") is run on the bottom in the producing formation. It is removable for easy cleaning when the slots become blocked by chemical deposits or rock particles.

Average cost of drilling is about $ 150 per meter.

The range of the total depth is 500-1000 m.

Other geothermal fields in New Zealand are Waiotapu and Kawerau, both of them under development. Many other thermal areas (including also Rabaul, in New Britain) have been recognized and are under investigation.

c. - The Geysers, California, U.S.A.

A total of 43 wells have been drilled in the Western United States for the exploration and exploitation of geothermal power. Drilled areas are The Geysers (now producing electric power by an automatic, 12.500 KW power plant), Casa Diablo (Mono County, California), Calistoga (Napa County, Cal.), Surprise Valley; Cal., Wabusta (Nevada), Steamboat Springs (South of Reno, Nevada), Brady Hot Springs (Nevada), Beowave, (Northern Central Nevada).

Papers of L. Decius and mc Nitt (1961) gives us a full account of the geothermal exploration in U.S..

A full discussion of the behaviour, interpretation and thermodynamic of the field can be found in a paper by Facca-Tonani, published in 1962 in the "Bollettino dell'Osservatorio Geofisico di Trieste". The space limitation forbids us to give here detailed account of this interesting subject.

4. - Exploration: methods and cost

Exploration for geothermal energy shows many analogies with oil exploration; the analogies dealt with the methods (geology, geophysics, drilling) and risk mentality, common to both industries. The main differences lie in the cost (the geothermal exploration is somewhat less expensive) and experience (the geothermal science is less advanced than petroleum science).

Geothermal prospection is generally carried out in 4 stages.

1. - Preliminary survey and selection of an area.
2. - Detailed survey on a selected prospect.
3. - Test drilling.
4. - Probing and evaluating.

Number 1 requires a regional general survey, comprising several stages:

a. - an economic study on the energy requirements and on the regional comparative cost of energy;
b. - a critical study of all available topographical, geological, geophysical and geothermal information;
c. - a detailed survey of the surface thermal shows;
d. - a preliminary servey of the stratigraphical series, with some general information about porosity and permeability, i.e. information about the possible stratigraphical. targets (cover and aquifer);
e. - the choice of the most promising area.

Point 1 requires about six months of work by a very experienced geothermal geologi geologist with the aid of a young geologist.

The range of the cost is in the range of $ USA 18.000-25.000-.

With point 2 begins the detailed reconnaissance, involving the work of several specialists. The most important works to be performed are:

a. - Detailed photogeology and field geology, volcanological studies, petrography and structure;
b. - detailed hydrogeochemistry and geochemistry and hydrogeology;
c. - evaluation of the minimum heat output; extent of the anticipated field;
d. - geophysical survey; each prospect needs a different program: electric, magnetic, gravimetric, thermometric and seismic methods can be useful, in accord with the geological data;
e. - all the above mentioned surveys will indicate a location for the first: exploratory well.

The cost of the operation under point 2 largely varies according to the geophysical program, which is the most expensive of all surveys.

The total cost of point 2 can easily be as high as $ 100.000-150.000.

Exploratory drilling (point 3) requires a first well and perhaps three or four additional wells, in the case of a successful first well.

We must remember that a single productive well does not prove an industrial field. But we must also remember that a single well can be put on production with a little plant and in the same time it will be able to prove the field and produce marketable energy.

The cost of an exploratory well is about $ 150 per meter; henceforth, exploratory drilling can be in the range of a minimum of 150.000 and a maximum of $ 600.000.- for three wells.

Point 4 (probing and evaluating) regards the output measurements and the determination of the working power of the fluids produced by the wells. The cost varies in a great range from field to field and can not be anticipated. It is not very high and it is required only when some industrial success is already obtained.

If the exploration has proven a commercial geothermal field, development and power plant construction will follow. Indications of the costs have been given.

We must emphasize that the point 1 (preliminary survey and selection of a favourable area) is not too expensive. The Governments and the large industrial companies which need energy (also in limited amount) can easily afford the preliminary surveys of the geothermal possibilities; the geothermal energy, with its very low cost, deserves full consideration before a decision about a major power plant is taken.

The Governments will be interested in a general inventory of the geothermal possibilities of their countries, as basic data concerning the agricultural, industrial and mineral development of the country.

5. - Geothermal energy and mineral resources.

Geothermal energy is associated to magmatic bodies intruded in the upper portion of the earth crust. Three types of geothermal fields are so far known; the first type represented by Larderello field, where the geothermal energy is related to a magmatic body without surface volcanic activity. The second type is represented by the Monte Amiata field, which is directly or indirectly associated with an extint Lower Quaternary volcano.

The third type, represented by Wairakei and The Geysers fields, is associated with active volcano.

We will observe that the Larderello field is about 70 km from the nearest extinct volcano, Mount Amiata; Monte Amiata is the northermost volcano of the region of great Quaternary volcanism along the Thyrrenian coast of southern Tuscany and Latium (M. Amiata, Tolfa, Bolsena, Bracciano, Vico Vulcani Laziali, Rocca Monfina). The stock of magma of Larderello is an intrusion which did not originate a volcano for lack of sufficient energy, but its relations with the volcanic framework of the Thyrrenian coastal region are out of discussion,

We can henceforth say that all the recent volcanic regions, with post-pliocene volcanoes, active or extinct, have geothermal possibilities. We point out also that the volcanic regions are often rich in mineral deposits; the Pacific volcanic belt is a classical example.

Geothermal energy can be an economic element of paramount importance in developping the mineral deposits.

6. - Conclusions.

The industrial value of the geothermal energy is no more in the realm of speculation: it is a proven reality. Its cost is competitive with all the other sources of energy; as a matter of fact, it is one of the cheapest, or the cheapest, source of energy.

Geothermal science is still in an initial stage, but in the very last years impressive progress has been made both in exploration and in esploitation; a reduction of cost and risks is resulting and a great expansion of the geothermal industry can be anticipated.

Preliminary investigations concerning the geothermal possibilities are not too expensive and they must be recommended in all volcanic regions of the world; also the areas with quaternary extinct volcanoes offer good possibilities of commercial geothermal fields.

Bibliographical indications

A section of the "United Nations Conference on the New Sources of Energy", held in Rome in August 1961, was dedicated to the geothermal energy. 77 specialized papers were presented by scientists of many countries; the papers covered all fields of geothermal science; they represent an invaluable source of economic, scientific and technological information. Previous literature is abundant, but scattered in many bulletins or rewiews of difficult access; we will mention only the important theoretical papers by J. Goguel, Le régime thermique de l'eau souteraine (Ann. des Mines, X, 1953, p. 3 a 32, Paris) and by G. Bozza, Sull'origine della termalità nelle acque e nel vapore endogeno (1961), privately printed by the geothermal Company "Larderello" in Italian, English and French.

Figures

1. - Geological cross section of the Larderello field (from Stefani, 1962, modified). 1 = Neogene. 2. - Flysch series. 3. - Evaporitic Triassic Series. 4. - Quartzitic Series. 5. - Basement.

2. - Developped and proven areas in Larderello geothermal field (by Burgassi, 1962). The field is not delimited and new producing areas will be discovered by exploratory drilling.

3. - Geological cross section of the Wairakei field (by Grindley, 1961). (1 = Ash showers and Alluvium. 2. - Siltstone and pumiceous sandstone, diatomite. 3. = Pumice breccia, non-welded lapilli crystal and vitric tuff. 4. = Waiora Valley andesite. 5. = Wairakei ignimbrite, dense green-gray quartzose ignimbrite (welded crystal tuff).

Fig. 1 G. FACCA - Geothermal energy exploration

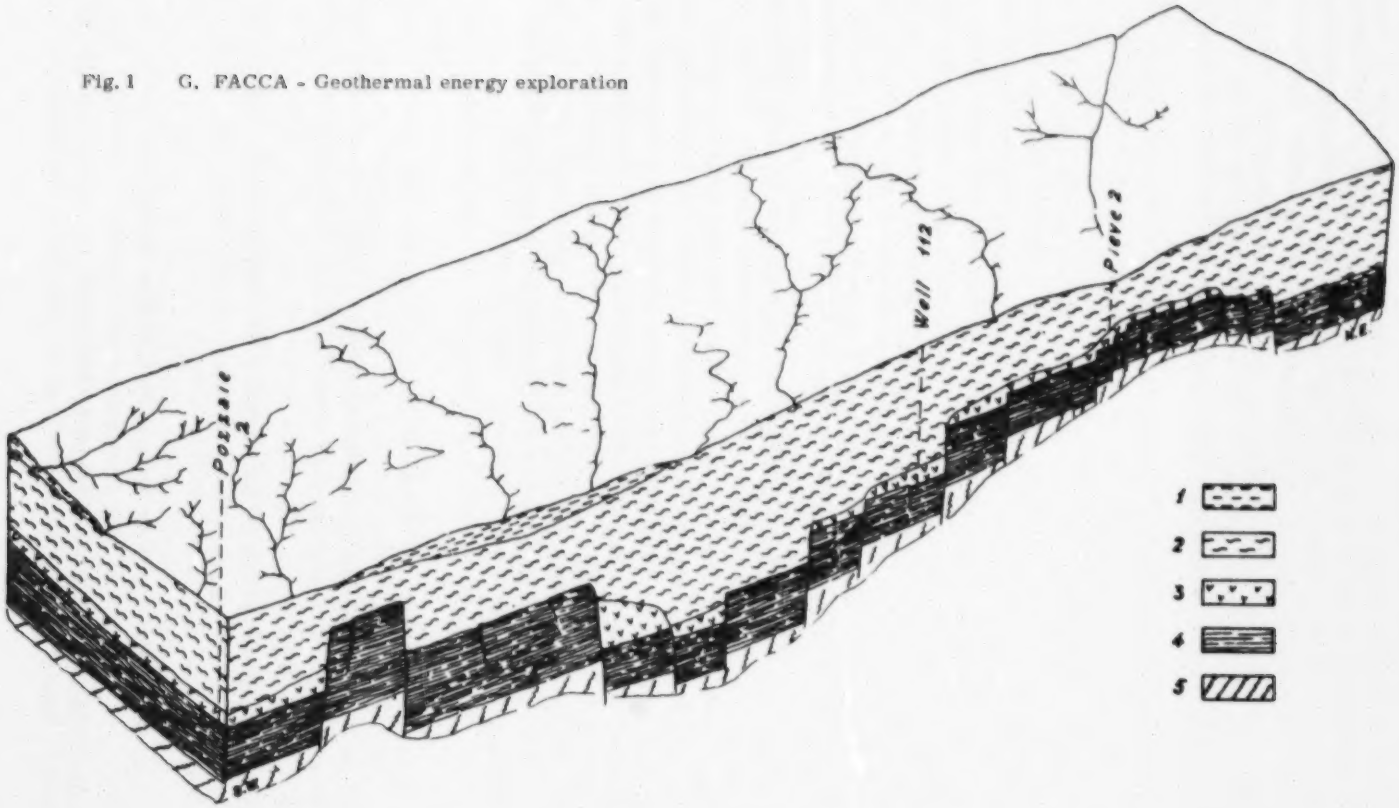
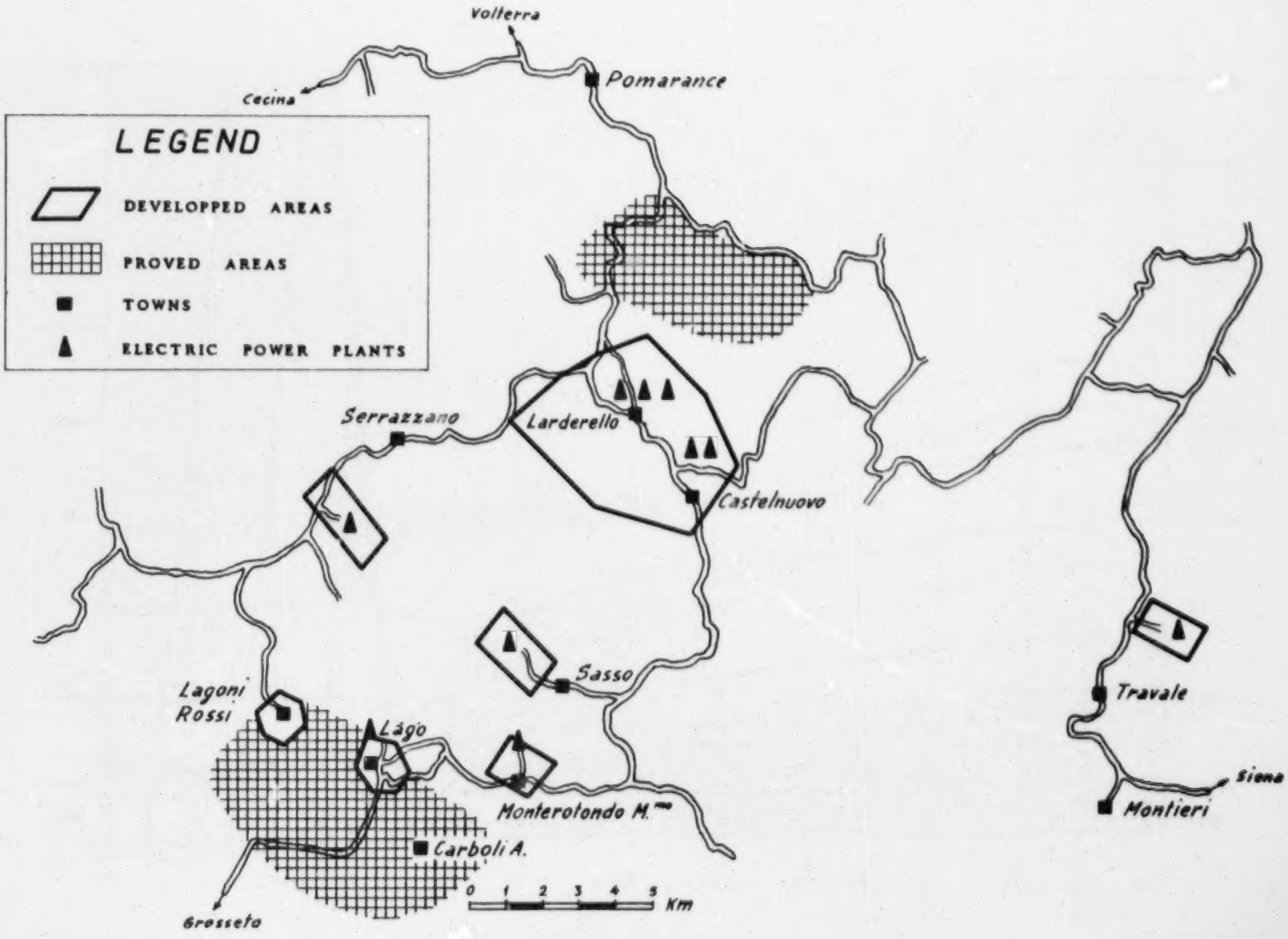
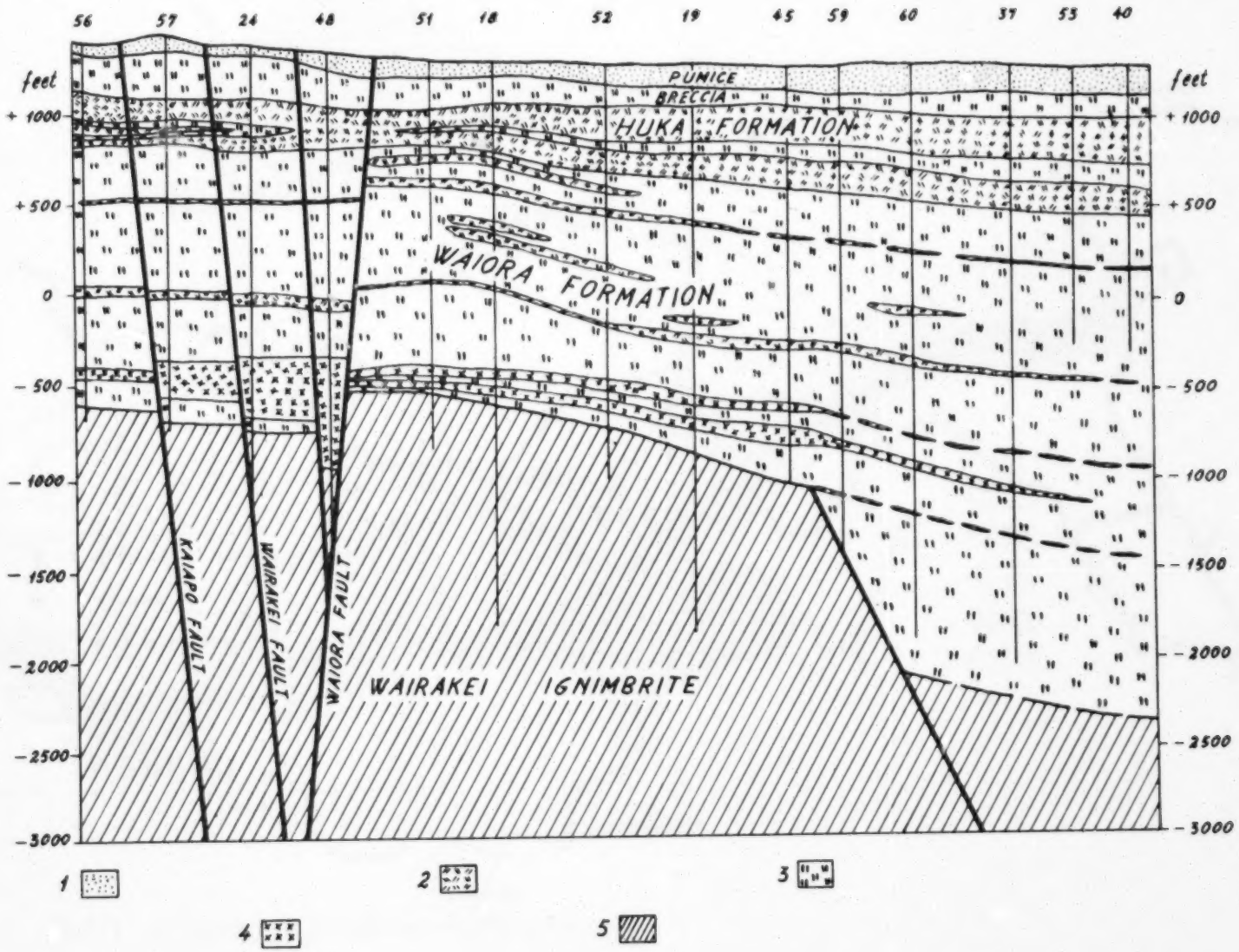


Fig. 2 G. FACCA. - Geothermal energy exploration





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E/CONF.39/A/321
2 Nov.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.5.2.2

United Kingdom

SOME RECENT DEVELOPMENTS IN THE MECHANISATION OF SMALL UNDERGROUND MINES

By D. SUTTON,
A.R.S.M., B.Sc., A.M.I.M.M.

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Some Recent Developments in the Mechanisation of Small Underground Mines.

by D. SUTTON A.R.S.M., B.Sc., A.M.I.M.M.

1. By force of economic necessity, few small metalliferous mines in the world today, however remotely situated or richly endowed with ore, can afford to ignore mechanisation in some degree for selected operations. This is especially true, perhaps, where the mineral products have to win acceptance in world markets rather than serve indigenous requirements for industry or stockpiling; but in all cases, considerations concerning expediency, an overall lowering of the average grade of ore available and the general price and scarcity of suitable labour indicate mechanisation as ultimately inevitable and have led to accelerating adoption of mining machinery on a world-wide basis in recent years.

2. The degree of mechanisation to be attempted in any particular case, however, together with optimum selection of equipment and working method, depend largely upon a unique assemblage of local conditions which themselves defy rigorous analysis. The problems involved are therefore far from straightforward and if the best results are to be obtained with a minimum of delay it is often wise to call on the experience of others.

3. But whose advice is to be sought? Every potential supplier of equipment will naturally have an interest in magnifying the suitability and importance of his own particular experience and equipment to the detriment of his competitors, thereby adding to the general uncertainty as to what is to be done. Experience can be, of course, acquired locally by trial and error procedures, but the expense in time and money will be unnecessarily large. Similar problems will usually have been encountered elsewhere but there again satisfactory solutions seldom become widely known. For these and similar reasons the best course to adopt probably lies in the use of professional consultants of high repute and even higher integrity noted for competent and impartial assessment, together with the engagement of skilled and experienced engineers who will be aware not only of the true potential of a mechanised operation but also of what is required in the way of additional workshop facilties, storekeeping and personnel.

4. However, even if full advangage is taken of the advice from all sources backed by the skill of experienced engineers it is natural that

the customer should wish to understand the basic reasoning behind the selection of a particular type of equipment or adoption of a particular working method, and it is for this reason that the more recent significant advances in equipment and technique are now summarised.

Shaft Sinking

5. When considering mechanisation of the initial shaft sinking stage of a mining operation it is necessary to offset expenditure on specialised sinking equipment against the saving in capital charges which result from an increase in the tempo of the work made possible by its use. On a cost per foot basis, especially in cheap labour areas, fully mechanised sinking may well prove more expensive than partial hand working, though a considerable overall saving may arise through achievement of an earlier return on invested capital.

6. Broadly speaking, mechanisation of the clearing of broken rock from the shaft bottom will only be considered where the total depth of sinking exceeds 1,000 ft. or so. Simultaneous sinking and lining, where applicable, will require greater depth still in order to effect overall economies. At the same time the small mine in shallow depth will be well advised to adopt other recent though less expensive time and labour saving techniques and to plan all operations in meticulous detail. For example, a suspended stage of simple design will be used for the installation of lining and shaft furniture, concrete for continuous or strip lining will be piped to the bottom directly from a surface batching plant, electric blasting from ring mains will be adopted, walls will be rock bolted where required as a temporary or perhaps permanent means of support and the work programme will be carefully tailored to suit cyclic operation on a 6 or 8-hour basis.

7. Drill jumbos mounting heavy machines remotely-controlled have found some application in small shafts in recent years but are an expensive luxury, even in most high wage-rate areas. Furthermore progress may be actually retarded due to their use since jumbos are unable to compete in overall drilling speed with hand-operated machines saturating the shaft bottom.

8. Outside the large mining groups more and more shaft sinking is being undertaken by specialist contractors who supply the necessary supervision and the more specialised items of equipment. Good results may also be obtained, however, using personnel recruited locally provided that suitable equipment is available and the entire project is placed in the hands of a thoroughly competent Master Sinker.

Lateral Development

9. The small mine will not usually wish to drive roadways exceeding 75 sq.ft. in cross-sectional area. Nor will it require ore and fill passes exceeding 50 sq. ft.

10. Drifting operations will be effected with greatest speed and economy by recourse to a modest expenditure in mechanisation. The drilling phase will be performed by percussive air-leg mounted machines preferably of 3 ins. bore. Unless the ground is exceptionally hard, taper-attached, detachable, tungsten carbide tipped chisel bits will be used in conjunction with 1 in. alloy steel rods. In very hard ground, integral steel will probably show an overall economy; in the hardest it will be essential.

11. Blasting will normally be undertaken by means of nitroglycerin-based explosives, safety fuse and igniter cord.

12. Broken rock will be loaded at the face by rail-mounted over-shot loader and suitable arrangements will be made for keeping the loader supplied with empty mine cars.

13. It is highly desirable to man a development end with versatile labour, so that one crew is capable of performing all operations at the face. The work may then be so planned that a full cycle of operations is completed within the span of a single shift: each crew enjoys a sense of accomplishment and in this way a high standard of overall performance is encouraged.

14. If the length of round and/or choice of equipment are such that either more or less than a full cycle of operations should be normally possible within a shift the speed of advance of the development end will be invariably affected adversely. Completion of one or two phases of the cycle within a shift is the next best objective for which to plan: although with such a system some sense of achievement is retained, apportionment of responsibility for sub-standard performance is rendered more difficult and the work programme becomes psychologically less conducive to sustained effort.

15. Raising is recognised as one of the more arduous and hazardous of underground mining operations, requiring above average skill and physical fitness from those assigned to it. Nevertheless it is doubtful whether the small mine would benefit appreciably from adoption of mechanised techniques unless elements such as speed or excessive length were a major consideration.

16. Where average raise length is of the order of 100 ft. or less it would be wise to investigate pre-drilling by long blast holes as a safe, low cost alternative to conventional raising methods, although a high degree of skill is required in obtaining and maintaining correct hole alignment for the method to be a success. At the same time the equipment required is standard and relatively inexpensive.

Ore Extraction

17. In the ultimate analysis, production from a mine depends upon the total length of working face available for mining attack and the mean intensity of its exploitation. The trend has been in recent years

towards a concentration of working places and a marked improvement in the tempo of extraction in each of them.

18. A factor of major importance in this connection has been the development of long hole drilling equipment which has been adopted on a very large scale and in a variety of applications, particularly for so-called "blast hole" stoping.

19. Hand in hand with improvements in drilling bits tipped with tungsten carbide have gone the development of specially treated fatigue-resistant extension steel rods and powerful percussive machines capable of operation in confined sub-levels. Using such equipment, holes may be drilled at any angle to depths of 100 ft. or so with ease, speed and acceptable cost.

20. Diamond drilling equipment has seen extensive use also in blast hole mining and renders comparatively trouble-free service. It tends, however, to be rather more expensive in overall cost per ton broken and for this reason its use is declining in favour of its percussive counterpart.

21. In most stoping operations at some stage the amount of expensive development footage required for access openings is related to the length of blast hole used in the extraction phase. It follows that, other things being equal, the longer the blast hole which it is practical to drill the lower will be the cost of access development, and it is precisely for this reason that the present tendency is to design working layouts with reference to a blast hole length of about 100 ft. This leads not only to important savings in access footage but to a less discontinuous cycle of operations and to a higher standard of safety within the stopes.

22. Aside from sub-level stoping, blast hole mining has been widely applied to the extraction of pillars and remnants, also to the isolation and undercutting of blocks of ground prior to caving.

23. Some shrinkage stoping has been successfully undertaken by means of horizontal fans of holes drilled from peripheral raises, also some sub level caving using vertical fans from more widely spaced access development.

24. Other significant though less important recent applications of long hole drilling equipment include the pre drilling of shallow shafts and raises and provision of conveyance holes for hydraulic fill, hoisting rope, electrical cables and drainage water.

25. "Satellite" mining opens up interesting possibilities. This new method involves the initial excavation of a parent opening from which, by means of partially charged long holes, parallel excavations radially disposed may be formed. Suitable layouts are used typically in stoping by room-and-pillar or by sublevel caving methods and savings in cost of up to 20 per cent. arise chiefly from the more efficient use of explosives.

Blasting with AN/FO Explosives

26. Close on the heels of the almost universal adoption of ammonium nitrate/fuel oil explosives for opencast mining purposes has come increasing recognition of the advantages in safety and cost to be gained through their use in small diameter boreholes underground.

27. Much research has been directed recently towards a better understanding of the properties of AN/FO mixtures in small borehole applications with particular reference both to safety and to their efficiency as blasting agents. From the results of all such research work published to date it is concluded that although AN/FO mixtures are sensitive to variations in composition, moisture content and strength of initiation, nevertheless dry, well-mixed, oxygen-balanced mixtures initiated by strong primers in well ventilated surroundings are very reliable and safe for use in small boreholes underground.

28. Both the mixing and the loading of AN/FO blasting agents have been effectively mechanised, adding further advantages in speed and cost to the very considerable saving in cost of materials as compared with nitroglycerine-based explosives.

29. AN/FO explosives are used to best advantage in dry ground where best results are obtained with a 60% NG explosive. Such explosives are unsuited, however, to tough ground normally requiring a high grade NG explosive, nor do they find satisfactory application in wet conditions such as exist for example, in shaft sinking and the bottom holes of development rounds. Their efficiency in shattered ground is also doubtful.

Ore Handling

30. Recent advances in the handling of broken ore and dry fill in the vicinity of the stope face, and from the face to the haulage drive have been less marked than elsewhere, but there has been a noticeable increase in the application of scrapers. The scraper, of course, is far from being a new device, but its modest cost, flexibility and useful capacity are being exploited on a larger scale than formerly.

31. In steeply inclined deposits, handling by gravity is naturally employed whenever possible consistent with the development footage involved and the cost of installing and maintaining numerous loading chutes, but in flat deposits scrapers are indispensable.

32. Loading machine draw points are losing ground in favour of scraper drifts. Drawpoints equipped with overshot loaders or scraper slides are capable of high outputs with well fragmented ore but lose this advantage when frequent stoppages are occasioned by secondary blasting. Since there is no storage between drawpoint and mine car with this system, any blockage due to large ore necessarily results in lost production and poor utilisation of an expensive machine.

33. In all stoping areas any apparent economy of small, hand-operated

loading boxes should be initially regarded as fallacious. Such devices are invariably an insufferable bottle neck expensive in labour, dynamite, maintenance charges and - above all - lost production. Loading boxes reward good design, generous dimensions and the modest expense of an air-operated chute door.

34. Steel loading boxes rock bolted in place have given good results for loading from shrinkage stopes. Installation and maintenance charges were both low and several re-uses were possible for the same box.

Ground Support

35. For undisturbed production, avoidance of dilution, high percentage extraction and good safety, close control of rock pressure and development of loose throughout the workings of the mine are obvious essentials.

36. In the general field of ground support over the past decade two developments have been outstanding, viz. rock bolting and hydraulic back filling.

Rock Bolting.

37. As a means of supporting the walls of shafts and the walls and backs of stopes and roadways, rock bolting has won universal acclaim. Bolting techniques are used to an increasing extent to compact the peripheries of tunnels through competent rock and also find application in rock which is inherently self-supporting to reinforce against pressure bursts.

38. In tunnelling operations through unstable ground, rock bolting has replaced both steel arch and timber support to some extent. In such applications the length of bolt used should be at least equal to the depth of round. Bolt Spacing is calculated from the load which can be safely placed upon each bolt together with the "dead weight" of the assumed rock volume to be supported. The safe working load is taken as 50 per cent. of the load at which the anchor yields or the bolt begins to deform plastically. For best results, bolts should be placed as soon after blasting as possible.

39. Effective anchorage is a function of the type of rock. In a sound, medium-hard rock the anchor will normally withstand a greater load than the bolt and the bolts may be stressed initially to 50 per cent. of their maximum permissible load. Where the rock is either soft, or very hard, however, effective anchoring may be difficult, rendering it impracticable to impart the desired working load to the bolt. In such cases either more closely spaced smaller diameter bolts with increased anchoring surfaces may be employed or the bolts grouted into place.

40. The simplest effective method of introducing grout into a bolt hole consists in merely ejecting the grout from a plastic "gun" under the action of a hand-operated plunger. The gun is inserted to the bottom of the hole, having been previously charged with grout of a suitable consistency by reverse action of the plunger. By judicious

selection of the size of the gun barrel the length of the ejection stroke may be made equal to the length of the grout anchor after insertion of the bolt, the requisite length having been previously determined from field trials.

Hydraulic Back Filling

41. As extraction proceeds in depth, it eventually becomes necessary to fill with waste material the voids created by removal of ore. This is done in order to stabilize the walls of the excavation, thereby facilitating the removal of pillars and the continuance of extraction in still greater depth.

42. Until comparatively recent times the fill material largely comprised sand, gravel, or broken rock imported into the mine from surface. These materials required surface excavation and transport, provision of fill passes into and within the mine, underground tramming to individual stopes and equipment for handling the fill in the stopes. Since the tonnage of fill required is about 60% of the tonnage of ore extracted it is obvious that stope filling operations add very appreciably to the working costs of the mine.

43. Great advantages in speed, cost and general expediency have been realised in recent years through the transport and placing of suitable fill material by hydraulic means. The fill material, usually mill tailing, after treatment in hydrocyclones to reduce the slime content is mixed on surface to a dense pulp averaging some 65% solids in water and as such it is supplied via boreholes and pipes direct to the stopes.

44. In cut-and-fill mining, the most important advantage of hydraulic fill is the saving in time required to fill a working floor thus shortening the non-productive part of the extraction cycle and increasing ore production in some instances by as much as 50%.
Other advantages include:-

(a) Elimination of expensive fill passes.
(b) Reduction of non-productive load on surface and underground transport facilities.
(c) Provision of a hard, level working floor in the stope.
(d) Extremely effective support of stope walls and stabilization of timber packs or square sets.

45. Provided a free-draining fill is used and that suitable precautions are taken to minimise delays due to blocked pipes, the method has no serious disadvantages.

46. It is obviously necessary when considering an application of hydraulic filling to ensure the availability of sufficient quantities of suitable fill material. By "suitable" is meant a sand having the following properties:-

(a) An initial percolation rate exceeding 2 inches per hour. Since some segregation during placement is inevitable it may by advisable to keep the percolation rate of the feed material above 4 inches per hour.

(b) Continued ability to drain in the presence of ground water. Due to re-orientation of the sand particles and to some migration of "fines" the percolation rate falls to a low value with time. Test should establish that the final percolation rate is acceptable.

(c) Sufficient strength after draining in cases where there is a requirement for pillar removal against sand-filled areas.
Sands consisting of angular particles of well-mixed sizes are best in this respect.

47. Hydraulic sand fill is usually obtained from mill tailing by removal of all but a few per cent. of -325 mesh material in hydrocyclones. Noxious or toxic substances must also be removed. With some treatment processes however, the tailings are so finely ground that the volume of contained +325 mesh material is inadequate, in which case the supply will have to be augmented with other suitable material, e.g. river sand, granulated slag.

48. Using 3 in. diameter pipes and boreholes, placing will be at rates approaching 1 ton of solids per minute, and it is normally possible to work on the surface of hydraulically placed fill ore hour after placing.

49. Continuous pipe runs of up to 13,000 ft. have been used for hydraulic fill in one instance with negligible pipe wear. Remote control of an entire delivery network by one man stationed in the stope has also proved successful.

Haulage and Hoisting

Diesel Haulage

50. Although electric battery and trolley locomotives are still widely used in the worlds underground metal mines, the adoption of diesel haulage is growing slowly.

51. Diesel-engined locomotives are self-contained and service is simple: operating and first costs are usually lower than with electric haulage and they are free of the limitations imposed by battery capacity or trolley wire installation.

Belt Conveying

52. Many more conveyor belt installations are to be foound in metal mines now than formerly, although transport by conveyor belt is best suited to flat orebodies and large outputs. Where a high load factor can be maintained, the conveyor belt offers the lowest cost per ton mile of horizontal haulage obtainable underground.

53. The practice of hoisting by conveyor incline has seen some application in metal mining in recent years. However, recent developments in high tension belts, and more particularly in the application of cable

belts, have reduced installation and operating costs still farther and make conveyor belt hoisting in moderate-depth more attractive.

Friction Drive Hoisting

54. Friction drive hoists have been adopted in metal mining increasingly over the past few years. As compared with drum-type hoists they possess several important advantages arising chiefly from the comparitively small size of the hoisting units and the simple incorporation of multiple ropes. Less rope wear results from elimination of multi-layer storage under high tensile loads and power requirements are often lower. Rope changes, however, are more difficult, rope lubrication must not be carried out and re-capping is impracticable. In the event of the shaft being deepened a new set of ropes would automatically become necessary.

Skip and Cage Hoisting

55. Ore removal from mines served by shafts is today invariably effected by skip hoisting. Compared to hoisting in mine cars, a large increase in shaft capacity is achieved at modest, if any, additional expense.

56. At the small mine, primary crushing is usually done on surface, in which case especially with ores which tend to break big, close attention must be paid to the provision and correct use of stope and ore-pass grizzleys. Underground crushing is usually only justified where the shafts are deep and the hoisting system highly automated.

57. In new skip hoisting installations the trend in recent years has been towards bottom and side - dump skips in preference to the overturning type. The former require less height in the headframe and tip more cleanly and evenly in a shorter time than the latter.

58. When initially planning the size of the main access shafts to a mine it is always good policy to provide for service cages of generous dimensions, so that the largest pieces of equipment likely to be required underground may be handled with ease and safety.

59. Aluminium alloys have been used to good advantage in cage and skip construction in recent years, reduction of the weight of the conveyance making for increased payload capacity and a useful saving in power cost per ton of ore hoisted.

60. Hoisting in general has become more fully automated in recent years, with improved electrical circuits replacing manual controls. Installation of remotely-controlled ore hoisting is one positive way of increasing shaft capacity at moderate cost.

Compressed Air Supply

61. For every ton of ore mined and concentrated in the modern metal mine something of the order of 3,000 cu.ft. of free air compressed initially

to 105 -110 p.s.i.g. is consumed. This forms an appreciable proportion of operating costs and it is therefore important that every economy in the use of this convenient though highly inefficient source of power should be observed.

Screw Compressors

62. Aside from the largest base load stations using turbo-compressors it now appears certain that the recently developed screw type of compressor will become standard equipment to the virtual exclusion of all others.

63. In comparison with a piston-type compressor, the screw machine requires considerably less floor space and absence of unbalanced forces reduces foundation requirements. Owing to the high speeds at which screw compressors operate they may be driven by comparatively inexpensive squirrel cage induction motors of high efficiency and good power factor. Furthermore, since bearings and timing gears are the only parts subject to wear, overhauls are infrequent and maintenance charges low.

Lighweight Piping

64. The use of aluminium or lightweight steel alloy pipes for both compressed air and water service mains underground has found favour in recent years. Compared to standard piping, the principal advantage of the new materials lies in a weight reduction of about 60 per cent which greatly facilitates handling and reduces the number and size of hangers required. Both types of piping are, however, prone to physical damage and corrosive attack for which there is no satisfactory remedy.

65. A reduction in price of polythene piping would make this material immediately attractive for use underground. Some is already in use in operations such as raising and hydraulic filling where requirements both as regards flexibility and extensibility are all-important.

Concentration of Output

66. Partly as a result of mechanised working, partly in order to take full advantage of the production potential which it affords, a marked concentration of higher intensity production from a smaller number of working places has come about in recent years.

67. Concentration of output has the overall effect of reducing the level of unproductive effort, both physical and mechanical, involved in the running of a mine, thereby tending to the best possible load factor on men and machines. Ventilation requirements are reduced and simplified; transport systems become less tenuous; mine services are reduced in extent and in maintenance requirements, and supervision is less dilute.

68. In metal mines, however, concentration of output can lead to difficulties with grade control and here, as elsewhere, concentration magnifies the deleterious effects of unforseen contingencies.

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